

NEW HAMPSHIRE

# MASSACHUSETTS COASTAL STUDY

ATLANTIC  
OCEAN

BOSTON HARBOR

MASSACHUSETTS

CAPE COD BAY

RHODE  
ISLAND

CAPE COD

BUZZARDS  
BAY

NANTUCKET SOUND

MARTHAS  
VINEYARD

NANTUCKET



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# MASSACHUSETTS COASTAL STUDY

## *PART I*

### *GENERAL*

#### *Authority*

At the request of the Executive Office of Environmental Affairs of the Commonwealth of Massachusetts, the New England Division of the Corps of Engineers has been asked to provide input to the Coastal Zone Management Office's water and related resources planning program for the coastal area of Massachusetts. The authority for this assistance is contained in Section 22 of the Water Resources Development Act (PL93-251) of 1974. Section 22 reads in part as follows:

"The Secretary of the Army, acting through the Chief of Engineers, is authorized to cooperate with any State in the preparation of comprehensive plans for the development, utilization and conservation of the water and related resources of drainage basins located within the boundaries of such State and to submit to Congress reports and recommendations with respect to appropriate Federal participation in carrying out such plans."

#### *Purpose*

This report is being prepared for the Commonwealth of Massachusetts, Coastal Zone Management Office, for the purpose of:

1. Providing information relative to the physical characteristics of the major storms (e.g., hurricanes and northeasters) that have occurred along the Massachusetts coastline during this century and damages associated with them.
2. Describing the role the Corps has played in providing shore protection and beach erosion control measures along the coastline of Massachusetts.

This information is for use as a planning tool by the Coastal Zone Management Office to assist them in their water and related resources planning program for the coastal area of Massachusetts.

## *Prior Studies and Reports*

A number of detailed investigations have been conducted and reports prepared by the New England Division of the U.S. Army Corps of Engineers, in the interest of beach erosion control, hurricane protection and related purposes along the Massachusetts coastline. As a result of these studies, a hurricane protection project was authorized and constructed for the New Bedford - Fairhaven area. A second hurricane protection project authorized by the Flood Control Act of 1962 for the Wareham - Marion area, due to a lack of local cooperation, was deauthorized in 1977.

For beach erosion control seven federal projects have been partially or totally completed in the following locations: Plum Island Beach, Newbury; Winthrop Beach, Winthrop; Quincy Shore Beach, Quincy; Wessagussett Beach, Weymouth; North Scituate Beach, Scituate; Plymouth Town Beach, Plymouth; and Oak Bluffs Town Beach, Martha's Vineyard; Massachusetts. Eight additional projects that have been authorized are located at: Lynn-Nahant Beach; Revere Beach; Nantasket Beach; Brant Rock Beach; Provincetown Beach; Thumpertown Beach; Town Neck Beach and Clark Point Beach. A detailed discussion of each of the above mentioned federally authorized and/or constructed hurricane and beach erosion control projects in Massachusetts is contained in subsequent sections of this report.

This report will concern itself with only the beach erosion control and hurricane protection studies by the Corps that have resulted in authorized or constructed projects. Several other studies have also been conducted by the Corps for various locations along the Massachusetts coast which did not recommend or result in an authorized project. Appendix A contains a complete list of the reports which have been prepared in the interest of beach erosion control, hurricane protection and related purposes along the Massachusetts coastline by the New England Division of the U.S. Army Corps of Engineers. Appendix B contains a glossary of terms used in this report.

# **PART II**

## **MAJOR STORMS WHICH HAVE AFFECTED THE MASSACHUSETTS COASTLINE SINCE 1900**

### ***General***

Even though Massachusetts is one of the smaller states in area, it has a relatively extensive coastline of about 1,200 miles including the shoreline of Cape Cod and the islands. Of this total about 935 miles or 78 percent is privately owned, 175 miles are publicly owned, and the remaining are owned by the federal government. Due to its location on the Atlantic coast in the northeast corner of the United States, as shown on Plate No. 1, the coastline is susceptible to two types of severe coastal storms. Hurricanes are the most destructive. Fortunately, they occur with less frequency than the other type of storms commonly referred to as "northeasters". This section of the report contains a general discussion of the physical characteristics of these storms, the coastal areas of Massachusetts most affected by them and damages they have caused.

### **HURRICANES**

When fully developed, hurricanes are the most destructive of all storms to strike the Massachusetts coastline. These major storms are inward-spiraling whirls of air which form over tropical waters. Once formed, northern hemisphere hurricanes often enter more northerly latitudes before they dissipate or metamorphose into ordinary extra-tropical storms. Hurricanes are characterized by centers of low barometric pressures, high winds speeds (75 miles per hour or greater), torrential rain, tremendous waves and extensive tidal flooding.

The wind in a hurricane progressively increases in speed as it spirals inward from the ill-defined periphery to very close to the edge of the "eye", or calm center within the storm. The shift from full intensity hurricane wind to the light wind associated with the eye is very abrupt as a hurricane passes over an area. The eye of a mature hurricane may have a diameter of from 10 to 30 or more miles. To the rear of the eye the wind increases again, but blows in the opposite direction to that in the advance sector. Generally, the second blow is not found to have as great an intensity as the first. The hurricane winds are accompanied by gray cloud covered skies and especially heavy driving rain. Thunder and lightning doesn't usually accompany hurricanes. Frequently, the rain is very heavy in the forward half and more moderate or even light in the rear, with usually no rain and possibly clear skies in the eye of the storm.

Most of the hurricanes that affect the eastern coast of North America are formed either near the Cape Verde Islands off the African coast or in the western portion of the Caribbean Sea. The Cape Verde storms pose the greatest threat to the New England area. Cape Verde hurricanes move westerly for a number of days with a forward speed of about 10 m.p.h. and generally, after reaching the middle of the Atlantic Ocean, recurve northerly and then easterly. Frequently they cross the West Indies, sometimes striking the eastern coast of the United States between Key West, Florida and Cape Cod, Massachusetts. After recurving, the storms usually increase their forward speed to a rate of 25 to 30 m.p.h. and occasionally to speeds of 40 to 60 m.p.h. The hurricanes which form in the Caribbean Sea generally move in a northerly direction and strike either the Gulf or the southeastern shores of the United States. The hurricane season is usually considered to extend from late June through mid-November, with the greatest threat to New England in August and September. The tracks of some of the most recent selected major hurricanes are shown on Plate No. 2 at the end of this report.

Hurricane wind speed is classically defined as 75 m.p.h. or faster. During almost every hurricane season wind speeds of 100 m.p.h. or higher have been found to occur in the tropics during one or more storms. Upon reaching the New England latitude, hurricane winds frequently weaken to maximum speeds of 60 m.p.h., comparable to severe winter "northeasters" or lesser storms. This degeneration of storms from full-fledged hurricanes in the tropics to a lesser intensity upon reaching New England makes the specification of the frequency of hurricanes in New England very difficult. Occasionally a tropical cyclone maintains full hurricane force of 75 m.p.h. or more upon reaching the New England area. Storms of this intensity pose the greatest threat to man and his activities, though the ones of lesser intensity, are by no means negligible along the coast or in areas susceptible to riverine flooding.

Hurricane winds have the ability to generate gigantic waves. The ultimate size of the wave is dependent on the force and duration of the wind and the distance the wave travels. Driven by hurricane winds, the breaking waves will run up on a beach or overtop vertical structures well above the actual stillwater height, so that reports of wave and flood damage from 5 to 25 feet above still water levels are not uncommon. The rise of the tide amounts to only 1 or 2 feet in the open ocean while its range can reach anywhere from 6 to 10 feet or more at coastal points.

The location of a storm track relative to a coastal community influences the magnitude of the surge. As hurricanes and other low pressure systems in the northern hemisphere rotate in a counterclockwise direction, the winds will be highest and southerly if the storm

center passes west of a community. On the east side of the storm track, the components affecting a surge, consisting of the forward speed of the storm, the high circulating hurricane winds and low barometric pressure are additive. Such conditions may cause abnormally high tides and waves that are often intensified at the heads of coves and bays. On the west side of the storm center, however, the counterclockwise rotation of the storm produces northerly winds which are generally in opposition to the storm movement. The resultant wind velocities are subtractive and usually smaller than those experienced on the east side where the components are additive.

The greatest hurricane disasters have resulted not from the wind or rain but from the tidal flooding which occurs in susceptible shore areas as a result of the wind driven hurricane tide and waves. The rise of the water level at the shore may begin when the hurricane center is 500 miles away. This rise is caused by the wind induced hurricane tide which is superimposed on the gravitational tide. Like the gravitational tide, the character and affect of the wind induced tide varies with the contour of the coast and the sea bottom. Hurricane tides are highest to the right of the point where the storm center passes inland and on concave shores may add three to ten feet to the level of the predicted gravitational tide. As the center of the hurricane comes into the shore zone, a second and often more destructive phenomenon occurs. This is the sharply rising hurricane wave which in its extreme form may add as much as 20 feet to the level of the combined hurricane and gravitational tides. The forces involved in setting up this wave are not entirely understood. A small part of the increase in water level undoubtedly results from the very low atmospheric pressures associated with the center of the hurricane, but this accounts, at the most, for a rise of only about four feet. When the hurricane tide and waves combine with the gravitational high tide, severe tidal flooding occurs in susceptible shore areas. The southern coastal areas of Massachusetts are particularly vulnerable to this type of tidal flooding and the associated wave, current and water damage.

The effect of hurricanes on land is most extreme in the coastal areas. Installations only a few feet above normal tides are often inundated and erosion due to wave, tidal and current action is often severe. Here too, the winds are the strongest, as they blow off the low-friction surface of the sea. Further inland, topographical irregularities and the general roughness of the ground impede the wind; however, wind damage may be both extensive and severe. Interference with transportation and communication, damage to trees and agricultural crops, damage to persons and dwellings from falling or flying objects and fallen wires and the damage to small craft

on interior lakes and ponds remain serious problems.

As was mentioned earlier, due to its physical location and configuration the coastal area of Massachusetts is affected by both "northeasters" and hurricanes. The south shore of Cape Cod, the outer islands and the Buzzards Bay area to the Rhode Island state line are exposed to southerly winds and hurricane generated surges which move up the Atlantic coast. The north shore of Cape Cod and the remainder of the north shore of Massachusetts is protected against the effects of these southerly winds and hurricane generated surges by Cape Cod; although, they are vulnerable to the effects of "northeasters". The history of hurricanes moving into New England show that for Massachusetts the hardest hit portion of the coastline is in the Buzzards Bay area from the Rhode Island state line to Falmouth, Massachusetts. Approximately 90 percent of the past hurricane tidal flood damages have been concentrated in this area.

The hurricanes that have caused the most severe tidal flooding along the Massachusetts coastline during this century, listed in their order of magnitude were those of 21 September 1938, 31 August 1954, 14 September 1944 and 12 September 1960. Table I gives the stillwater tidal elevations in feet above mean sea level (m.s.l.) at various points along the south shore of Cape Cod and at Boston associated with these major events. A more detailed discussion of the physical parameters associated with these storms, the areas which have been most adversely affected by them and the type and amount of damages that have been sustained as a result of these storms is contained in the subsequent section of this report entitled "Storms".

TABLE I  
HURRICANE STILLWATER TIDAL ELEVATIONS  
AT SELECTED LOCATIONS ALONG THE MASSACHUSETTS COASTLINE

Still Tidal Elevations in Feet Above Mean Sea Level

<u>Storm Date</u>	<u>Wood's Hole*</u>	<u>Chatham (outer shore)</u>	<u>Truro (Ballston Beach)</u>	<u>Provincetown (Race Pt.)</u>	<u>Boston</u>
21 Sept. 1938	9.2	5.9 <sup>+</sup>	6.1 <sup>+</sup>	6.5 <sup>+</sup>	6.4
14 Sept. 1944	11.0	7.7 <sup>+</sup>	7.6 <sup>+</sup>	7.6 <sup>+</sup>	7.1
31 Aug. 1954	9.4	7.7 <sup>+</sup>	7.9 <sup>+</sup>	8.3 <sup>+</sup>	8.4
12 Sept. 1960	5.5	5.2 <sup>+</sup>	5.5 <sup>+</sup>	6.0 <sup>+</sup>	6.8

Note: \*Indicates observed tide levels. Unless indicated by asterisk (\*), tide elevations along the outer Cape Cod are estimates based upon tidal constants published by the National Ocean Survey (formerly Coast and Geodetic Survey), experienced tides at the Boston reference gaging station and meteorological data.

### NORTHEASTERS

The north shore of Cape Cod and the remaining shorefront of Massachusetts north of the Cape have not experienced serious hurricane damages in the past; however, these areas are vulnerable to the more frequent but lesser magnitude winter storms commonly referred to as "northeasters". The northeaster is much like the hurricane, in that it is typically generated in the tropical area of the Caribbean and follows a coastal route towards New England. It usually has accompanying high winds, though not normally of hurricane force, not is it as well defined a storm as a hurricane, sometimes stretching over 600 miles in diameter. The storm is usually associated with heavy precipitation in the form of snowfall in New England, with amounts ranging up to 3 to 4 feet or more in severe storms. The slow movement of these storms, sometimes causing them to remain in the New England area for two or three days, increases the coastal damages associated with them since several tidal changes may occur at near gale conditions with high tides ranging up to 10 feet above normal.

The northeasters which produce the strong winds and high tidal surges along the New England coast are well developed extratropical lows. The gross features of a typical northeaster are made up of a single center of low pressure associated with one cold and one warm front. By the time these storms reach the New England area they are usually in the initial stage of occlusion which occurs when a cold front overtakes a warm front and lifts the warm air above the earth's surface. The more complex northeasters are characterized by more than one center of low pressure in conjunction with a family of occluded cold and warm fronts. Pressure fields associated with surge producing northeasters are noticeably unsymmetrical. The degree of unsymmetry is dependent upon various factors, such as the extent to which the storm has occluded, the nature of the underlying surface when part of the storm circulation is over land, the affects of the upper air circulation and the influence of surrounding systems. Many of the more severe surge producing northeasters have been associated with blocking high pressure areas located ahead of the storm which impede their forward motion.

The zone of strongest winds in any particular storm is usually found in the forward semi-circle of the moving storm; but it may also be found in the rear semi-circle, particularly to the left. The distance of this zone from the center is variable, but normally is in the range of from 90 to 340 miles. In addition, there is often a secondary belt of maximum winds (of lesser value, but still distinct and well substantiated by observations). The lesser

maximum is usually at a greater distance from the center than the principal maximum belt. Observed wind speeds of 63 to 69 m.p.h. are not unusual in these mature storms. In many of the more severe northeasters, the zone or area of strongest winds covers large portions of coastal regions.

Along the New England coast, two peaks of storm activity have been found to occur; one in December and the other in February. These maxima are not very pronounced since cyclone activity is high from November through March.

Northeasters usually occur as a result of rapid cyclogenesis along the Gulf of Mexico and Atlantic coastal areas. Cyclogenesis is defined, in this case, as the development of a low pressure system at the surface. The maximum occurrences of cyclogenesis in these regions takes place during the colder months when the temperature differential between maritime and continental air masses along these southern coasts is the greatest.

Typical tracks that may be taken by a northeaster which affects the Massachusetts coastline are shown on Plate No. 3 at the end of the report. The severe northeast storms of 19-20 February 1972, 20 January 1961, 30 December 1959 and 26 December 1909 have been selected for further detailed discussion in a later section of this report. Table II contains the stillwater tidal elevations in feet above m.s.l. at various points along the south shore of Cape Cod and at Boston associated with these four northeasters.

TABLE II  
STILLWATER TIDAL ELEVATIONS OF MAJOR NORTHEAST STORMS AT SELECTED  
LOCATIONS ALONG THE MASSACHUSETTS COASTLINE

<u>Stillwater Tidal Elevations in Feet Above Mean Sea Level</u>					
<u>Storm Date</u>	<u>Woods Hole*</u>	<u>Chatham (Outer Shore)</u>	<u>Truro (Ballston Beach)</u>	<u>Provincetown (Race Pt.)</u>	<u>Boston</u>
26 Dec. 1909	-	-	-	9.8*	10.6
29 Dec. 1959	3.9	7.9 <sup>±</sup>	8.2 <sup>±</sup>	9.0*	9.3
20 Jan. 1961	3.4	7.5 <sup>±</sup>	7.9 <sup>±</sup>	8.5 <sup>±</sup>	8.9
19-20 Feb. 1972	5.1	7.0 <sup>±</sup>	7.3 <sup>±</sup>	8.1 <sup>±</sup>	9.1

Note: \*Indicates observed tide level. Unless indicated by asterisk (\*), tide elevations along outer Cape Cod are estimates based upon tidal constants published by National Ocean Survey (formerly Coast + Geodetic Survey), experienced tides at the Boston reference gaging station and meteorological data.

## *Storms*

This section of the report is intended to give a detailed discussion of four selected hurricanes and four northeast storms which have adversely affected the Massachusetts coastline during this century. The discussion includes a detailed description of the physical parameters associated with these storms, the areas most adversely affected by them and the damages which resulted due to them.

The tables presented with the individual hurricane descriptions and showing damage figures for the respective hurricane were developed to demonstrate the magnitude of damages caused or expected to occur as a result of major hurricanes in specific coastal areas of Massachusetts. Damage surveys performed by and for the New England Division of the U.S. Army Corps of Engineers, are the source of these figures which have been compiled by the Corps Economic and Social Analysis Branch.

Data for the 1938, 1944 and 1954 hurricanes are based on surveys performed after hurricane "Carol" which occurred in August 1954. The data has been broken down as far as possible whenever the information was available in order to emphasize the distribution of damages by type as well as location. In some instances the files were found to be incomplete with the result that the total damage figures shown in this report are somewhat lower than other estimates of damages attributed to these storms.

The figures for the 1960 hurricane were taken from a post-flood damage survey conducted by the New England Division Office. The tables present figures for both recurring as well as experienced damages whenever the information was available in the files. Experienced losses are defined as those that occur at the time of and as a result of a specific storm event. On the other hand, recurring losses are defined as those losses which are expected to occur, based on a particular level of economic activity and a particular flood height in a specific area. When making as estimate of recurring losses it is necessary to take into account the effects of the referenced event on the area under study, changes in the development of the area that have occurred since the referenced event and protective structures, if any, which have been constructed in the area. However, in order to take these items into account in computing recurring losses it is necessary to conduct extensive field surveys. Such surveys are beyond the scope of this study.

The recurring losses cited in the tables for the 1938, 1944, and 1954 hurricanes are based on conditions existing in 1956. The significance of recurring loss figures usually decrease with time starting from the referenced event due to the changes in

development that is found to occur over the years. Based on this it was felt that it would not be beneficial to develop estimates of recurring losses for 1978 based on 1956 conditions because no extensive field damage surveys have been conducted by the Corps office since the one done after the 1954 event. However, the figures have been updated to reflect 1977 price levels to account for the affects of inflation. It should be pointed out that these figures should not be compared with other estimates which may have been developed based on more recent studies.

The figures are useful for comparing the extent of experienced or recurring losses for each event, for pointing out the magnitude of damages that can result from a major hurricane and for indicating the areas along the Massachusetts coastline which are most vulnerable to the effects of these major events.

Unfortunately, with the exception of the December 1959 northeaster, the Corps office has not conducted extensive field damage surveys for severe northeast winter storms. Therefore, the Corps files do not contain as much comprehensive damage information for the north-easters discussed in this report, as for the hurricanes. However, after severe northeast storms the Corps is often asked by the Federal Disaster Assistance Administration (formerly known as the Office of Emergency Preparedness) to conduct damage surveys. These damage surveys concentrate on publicly owned and operated facilities and structures and do not cover damages incurred by the private sector. Thus, it should be kept in mind that the damage figures shown in this report for northeast storms are not all-inclusive.

It should be noted that the damage figures shown in this report for both hurricanes and northeasters mainly reflect damages along the coast caused by tidal flooding and wave action. Inland damages caused by strong winds, heavy rainfall and riverine flooding would need to be added to the figures in this report to get an estimate of the total damages attributed to a particular event.

The New England Division of the U.S. Army Corps of Engineers prepared a hurricane survey interim report entitled "Massachusetts Coastal and Tidal Areas", dated 5 August 1964. A number of drawings prepared for the report show the extent of areas along the entire Massachusetts coastline which would be subject to tidal flooding during severe storm activity such as accompanies hurricanes and northeasters. These drawings, reproduced on Plates 4 thru 9 at the end of this report, have been updated for the area of the New Bedford - Fairhaven hurricane barrier to reflect the degree of protection that is afford by the barrier. The amount of effort, including extensive field survey work, and funds necessary to update all of the plans is beyond the scope of this report.

### September 1938 Hurricane

The most severe hurricane of record for the New England area occurred in September 1938 and caused tidal flooding of over 14 feet above mean sea level and a loss of 187 lives. The maximum gust of wind recorded for this hurricane in New England was 186 miles per hour. This maximum gust was recorded at the Blue Hill Observatory in Milton, Massachusetts. In addition, a sustained 5 minute wind speed of 121 mph was also recorded for this storm at the Blue Hill Observatory.

The hurricane originated around the Cape Verde Islands and traveled on a curved path in a northwesterly and then northerly direction off the Atlantic coast until it reached the New England area. Then on the afternoon of 21 September the storm suddenly struck inland from the ocean and crossed the coast of Connecticut, where gale winds and ocean inundation caused almost unimaginable damage along the thickly populated shores as far west as New York City and as far east as Chatham on Cape Cod, Massachusetts. If it had not been for the fact that many summer residents had returned to their homes soon after Labor Day, the loss of lives would have been appalling. The hurricane continued northward with almost unabated force through Connecticut and Massachusetts and then, gradually diminishing, crossed the Green Mountains in Central Vermont, and passed into Canada near Lake Champlain, as shown on Plate No. 2. It left behind a ravaged countryside extending scores of miles eastward from its central path. The eastern edge of the storm track, the most severe area in terms of wind and wave damage was positioned directly along the Massachusetts coast. The resulting damage from wind driven waves which were coincident with the high tide occurring at the time caused disastrous results along the shore area, destroying beaches, headwalls, wharves, buildings and beaching numerous craft.

Extensive field damage surveys were not conducted following the 1938 hurricane by the Corps. Therefore, there is not a significant amount of information regarding damages actually sustained as a result of the storm in the files at the Corps' New England Division Office. However, recurring loss figures have been developed for the 1938 hurricane using 1956 conditions and price levels. These figures are shown in Table III as well as an update of these figures to 1977 price levels to reflect the effects of the inflation that has occurred over this 21 year time span.

TABLE III  
RECURRING TIDAL FLOOD DAMAGES FOR THE 1938 HURRICANE ALONG  
MASSACHUSETTS COASTAL AND TIDAL AREAS  
(Thousands of Dollars)

<u>LOCATION</u>	<u>1956 Price LEVELS</u>	<u>1977 Price LEVELS</u>	<u>REMARKS</u>
<u>Buzzards Bay Area</u>			
Acushnet, Fairhaven and New Bedford (Excluding Sconticut Neck and West Island)	33,000.0	97,020.0	Damages were mainly sustained by commercial and residential property and structures.
Dartmouth	1,197.7	3,521.2	However, in some communities such
Marion	2,656.8	7,811.0	as New Bedford
Mattapoissett	2,722.9	8,005.3	and Acushnet, industrial damages
Wareham	9,564.5	28,119.6	were found to be
Westport	634.0	1,864.0	extensive and accounted for the major portion of the losses.
<u>Cape Cod Area</u>			
Barnstable	76.5	224.9	The losses were predominantly due
Bourne	2,506.6	7,369.4	to flooding of residential properties.
Dennis	18.2	53.5	Damage to commercial properties, public
Falmouth	1,293.8	3,803.8	property and trans- portation facilities
Harwich	6.2	18.2	such as highways and railroads accounted
Mashpee	5.9	17.3	for most of the remain- ing losses.
<u>Offshore Islands</u>			
Nantucket	73.8	217.0	
Martha's Vineyard	<u>332.5</u>	<u>977.6</u>	
Totals	54,089.4	159,022.8	

### September 1944 Hurricane

On 14 September 1944, the New England area was struck by a tropical hurricane which originated in the West Indies. It traveled in a northwesterly then northerly direction to Cape Hatteras, thence swerved north northeast across Long Island, reaching the mainland in the vicinity of Westerly, Rhode Island. The storm center passed inland between Charlestown and Point Judith, Rhode Island at 10:20 p.m., EST, on the 14th and moved in approximately a straight course, passing between Fall River, Massachusetts and Providence, Rhode Island. The storm was proceeding at about 36-37 mph and arrived at South Weymouth, Massachusetts just past midnight. At this point the wind shifted direction from southeast to west. The center then passed out to sea, over Massachusetts Bay, moving very near the tip of Cape Ann, then across the Gulf of Maine and again entered the mainland near Bar Harbor as shown on plate No. 2. The damaging effects of the storm were of moderate severity some 50 miles to the northwest of the track center over southern New England. Over the region to the southeast of the track center, the damage was extreme and in some cases, tragic. In New England alone, there were some 40 deaths from the storm. The light vessel "Vineyard" was dragged from her station and sunk about two miles to the northwest. Some 4,000 houses were seriously damaged or destroyed. Luckily, the high tide did not coincide with the rolling up of the storm tide, and this averted an immense amount of destruction along the coast, which might have equaled the 1938 storm. During the course of the storm a maximum sustained wind intensity of 82 mph was recorded with a gust of 104 mph at Chatham, Massachusetts.

The southeast quadrant of the storm embraced the southeastern parts of Plymouth and Bristol counties and western Barnstable County. It was in these areas where the greatest damage was wrought as a result of the high winds. There was evidence of one or more small tornados in the turmoil of the air stream recorded at Nantucket, Boston, Rockport and Cape Cod light. Some groves of trees had been leveled off by breaking and uprooting while little tree damage was occurring nearby. Precipitation varied between 2-4 inches across the Massachusetts coastal area.

Extensive field damage surveys were not conducted by the Corps following the 1944 hurricane, therefore, there is not a significant amount of information concerning damages which were sustained as a result of the storm in the files at the Corps' New England Division Office. However, recurring losses for the 1944 hurricane based on the damage survey after the 1954 hurricane have been computed with an up date to 1977 prices to reflect the affects of inflation. Table IV gives the recurring losses for hurricane tidal flooding along the Massachusetts coastal and tidal areas associated with September 1944 hurricane.

TABLE IV  
RECURRING TIDAL FLOOD DAMAGES FOR THE 1944 HURRICANE ALONG  
MASSACHUSETTS COASTAL AND TIDAL AREAS  
 (Thousands of Dollars)

<u>LOCATION</u>	<u>1956 Price LEVELS</u>	<u>1977 Price LEVELS</u>
<u>Buzzards Bay Area</u>		
Acushnet, Fairhaven & New Bedford (Excluding Sconticut Neck and West Island)	1,550.0	4,557.0
Dartmouth	121.4	356.9
Marion	187.4	551.0
Mattapoissett	183.0	538.0
Wareham	549.1	1,614.4
Westport	126.9	373.1
<u>Cape Cod Area</u>		
Barnstable	979.3	2,879.1
Bourne	100.1	294.3
Chatham	35.3	103.8
Dennis	492.4	1,447.7
Falmouth	2,850.3	8,379.9
Harwich	146.5	430.7
Mashpee	228.5	671.8
Yarmouth	225.6	663.3
<u>Offshore Islands</u>		
Nantucket	856.6	2,518.4
Martha's Vineyard	<u>332.5</u>	<u>977.6</u>
Totals	8,964.9	26,357.0

### September 1954 Hurricane

Hurricane "Carol" hit New England on the 31st of August, 1954 with an intensity comparable to the great hurricane of September 1938 and with wind and water damage of similar catastrophic proportions. It caused approximately sixty fatalities and 100 injuries, far less than in 1938, but resulted in property and crop losses estimated at \$454,550,000. Over 10,000 buildings and 3,000 small craft were destroyed or seriously damaged. Electric service was disrupted in approximately a thousand communities and more than a million telephones were put out of operation. These facts show that the magnitude of the storm ranks with the most severe weather occurrences on record for New England.

Speeding north-northeastward from a central position off the Virginia coast at midnight of the 30th, the hurricane swept over extreme eastern Long Island nine hours later. The path of the center took it into New England at the mouth of the Connecticut River about 10:30 a.m., EST. Moving up through extreme eastern Connecticut, the center passed just west of Worcester, Massachusetts about noon. Curving more to the north, the track of the center reached into south central New Hampshire about 1:30 p.m. The storm continued on through New Hampshire and passed into Quebec around 8 p.m., at which time the weakened storm was no longer of hurricane force. The track of the storm is shown on Plate No. 2.

"Carol" was extremely violent during the morning over the region extending eastward 100 miles from the center of the storm track. Sustained hurricane winds with gusts to 125 mph ravaged eastern Connecticut, Rhode Island and Massachusetts from the Webster - Worcester - Fitchburg line to the elbow of Cape Cod. This thickly populated area, with numerous vacationists thronging its beach resorts, sustained the bulk of the property devastation and most of the deaths and injuries. Added havoc was suffered along the coast as storm waves rushed ashore, destroying pleasure craft and summer cottages by the thousands. Throughout this area, countless trees were toppled, blocking roads, smashing buildings and automobiles and wrecking electric and telephone lines. Wind damage to roofs, chimneys, steeples, aerials, signs, windows, radio and television towers was enormous. All forms of transportation were crippled.

As "Carol" swept across New England a sustained maximum wind intensity of 80 mph was recorded at Block Island, Rhode Island, with a recorded peak gust of 135 mph. Flood tides reached heights of approximately 14 feet above mean sea level along the south shore of Cape Cod. The rainfall was extremely light for a storm of such intensity, dropping only 2-5 inches over the area.

Following the 1954 storm the New England Division of the U.S. Army Corps of Engineers conducted extensive field damage surveys along the coastal and tidal areas of Massachusetts. Damage figures obtained from those surveys are contained in Table V. Table VI contains figures for recurring losses which maybe expected to occur using 1956 as a base year. Both tables contain updated figures to 1977 price levels to reflect the effect of inflation that has occurred over the 23-year period.

TABLE V  
EXPERIENCED TIDAL FLOOD DAMAGES FOR THE 1954 HURRICANE  
ALONG MASSACHUSETTS COASTAL AND TIDAL AREAS  
(Thousands of Dollars)

Location	(1) Residential	(2) Commercial	(3) Public	(4) Urban	(5) Industrial	(6) Railroad	(7) Highway	(8) Transportation Other	(9) Utility	(10) Unspecified	1954 Price Level Total	1977 Price Level Total
<u>Buzzards Bay Area</u>												
Acushnet	-	-	-	10.0	290.0	-	-	-	-	-	300.0	960.0
Dartmouth	803.3	352.1	69.0	-	-	96.0	-	-	-	-	1,320.4	4,225.3
Fairhaven	6,466.5	646.7	110.0	-	900.0	-	-	60.0	-	180.0	8,363.2	26,762.2
Marion	1,740.2	316.1	318.5	-	27.0	-	-	-	-	-	2,401.8	7,685.8
Mattapoisett	4,350.2	317.3	30.5	-	21.6	-	-	-	-	-	4,719.6	15,102.7
New Bedford	600.0	1,050.0	375.0	-	10,500.0	-	-	-	-	-	12,525.0	40,080.0
Wareham	6,218.6	1,470.8	206.0	-	234.3	22.0	27.2	-	-	-	8,178.9	26,172.5
Westport	1,491.3	300.0	15.0	-	-	-	16.6	-	-	-	1,912.9	6,121.3
								90.0	-	-		
<u>Cape Cod Area</u>												
Barnstable	350.0	84.0	10.0	-	-	-	-	-	-	-	444.0	1,420.8
Bourne	764.4	142.7	109.7	-	-	-	4.2	-	-	-	1,021.0	3,267.2
Chatham	20.0	28.0	-	-	-	-	-	-	-	-	48.0	153.6
Dennis	115.0	96.0	71.8	-	-	-	-	-	-	-	282.8	905.0
Falmouth	1,137.4	454.0	283.0	-	-	5.6	56.6	-	-	365.9	2,302.5	7,368.0
Harwich	54.6	118.0	11.8	-	-	-	-	-	-	82.2	266.6	853.1
Mashpee	66.8	-	34.0	-	-	-	14.6	-	-	-	115.4	369.3
Orleans	5.0	-	-	-	-	-	-	-	-	-	5.0	16.0
Provincetown	5.0	24.0	172.0	-	-	-	-	-	-	-	201.0	643.2
Yarmouth	307.4	37.5	68.0	-	-	-	2.4	-	-	-	415.3	1,329.0
<u>Mount Hope Bay</u>												
Fall River	87.3	488.4	335.6	-	2,010.0	-	-	-	320.0	-	3,241.3	10,372.2
Somerset	291.3	66.8	5.8	-	420.0	-	40.0	-	-	-	823.9	2,636.5
Swansea	650.0	80.0	2.0	-	12.5	-	-	7.0	-	-	751.5	2,404.8
<u>Narragansett Bay</u>												
Assonet - Freetown	-	-	-	190.0	70.0	-	-	-	-	-	260.0	832.0
Berkley	-	-	-	225.0	-	-	-	-	-	-	225.0	720.0
Dighton	307.5	134.6	15.3	-	344.3	-	-	6.3	-	-	808.0	2,585.6

TABLE V (CONT.)  
EXPERIENCED TIDAL FLOOD DAMAGES FOR THE 1954 HURRICANE  
ALONG MASSACHUSETTS COASTAL AND TIDAL AREAS  
(Thousands of Dollars)

Location	(1) Residential	(2) Commercial	(3) Public	(4) Urban	(5) Industrial	(6) Railroad	(7) Highway	(8) Transportation Other	(9) Utility	(10) Unspecified	1954 Price Level Total	1977 Price Level Total
Offshore Islands												
Nantucket	149.0	23.1	-	-	-	-	-	-	-	6.5	178.6	571.5
Martha's Vineyard												
Chilmark	-	8.7	-	-	-	-	59.0	-	-	23.3	91.0	291.2
Edgartown	77.4	66.2	-	-	-	-	-	-	-	59.7	203.3	650.6
Oak Bluffs	59.7	47.7	-	-	-	-	3.8	-	-	-	111.2	355.8
Tisbury-Vineyard Haven	10.8	104.0	-	-	-	-	-	-	-	6.2	121.0	387.2
Totals	26,128.7	6,456.7	2,243.0	425.0	14,829.7	123.6	224.4	163.3	320.0	723.8	51,638.2	165,242.4

FOOTNOTES

- (1) Damages to or loss of houses and associated property (e.g. yards, garages, furniture, etc.)
- (2) Damages to or loss of retail stores and businesses such as department stores and restaurants.
- (3) Damages to or loss of public property such as government buildings, parks, memorials, wharfs, piers, seawalls, bulkheads, etc.
- (4) Damages to or loss of residential, commercial and public property in urban areas not included in the previous three categories.
- (5) Damages to or loss of industrial property such as factories and related grounds, offices and machinery.
- (6) Damages to or loss of railroad tracks, trains, cars, stations and other properties.
- (7) Damages to or loss of roadways, bridges, etc.
- (8) Damages to or loss of transportation facilities. May include damages to railroads, highways, ships, ports, etc.
- (9) Damages to or loss of utilities such as water and power.
- (10) May include damages in any of the preceeding categories as well as other miscellaneous losses.

Table VI  
RECURRING TIDAL FLOOD DAMAGES FOR THE 1954 HURRICANE  
ALONG MASSACHUSETTS COASTAL AND TIDAL AREAS  
(Thousands of Dollars)

Location	(1) Residential	(2) Commercial	(3) Public	(4) Urban	(5) Industrial	(6) Railroad	(7) Highway	(8) Transportation Other	(9) Utility	(10) Unspecified	1956 Price Level Total	1977 Price Level Total
<u>Buzzards Bay Area</u>												
Acushnet	-	-	-	10.0	290.0	-	-	-	-	-	300.0	882.0
Dartmouth	596.1	337.7	-	-	-	96.0	-	-	-	-	1,029.8	3,027.6
Fairhaven	-	-	-	-	-	-	-	-	-	4,150.0	4,150.0	12,201.0
Marion	1,531.2	271.1	318.5	-	-	-	-	-	-	-	2,120.8	6,235.2
Mattapoissett	2,047.5	267.8	5.9	-	-	-	-	-	-	-	2,321.2	6,824.3
New Bedford	111.6	15.6	69.8	-	1,179.8	-	-	-	-	-	1,376.8	4,047.8
Wareham	2,999.0	1,018.5	140.7	-	234.3	22.0	27.2	-	-	-	4,441.7	13,058.6
Westport	281.7	260.4	-	-	-	-	15.6	-	-	-	557.7	1,639.6
<u>Cape Cod Area</u>												
Barnstable	252.3	62.7	-	-	-	-	-	156.8	-	-	471.8	1,387.1
Bourne	718.9	146.7	190.7	-	-	-	-	-	-	-	975.3	2,867.4
Chatham	3.5	-	-	-	-	-	-	-	-	-	3.5	10.3
Dennis	164.3	40.1	-	-	-	11.0	-	-	-	0.3	215.7	634.2
Falmouth	1,453.1	525.6	-	-	-	-	-	58.8	-	369.2	2,406.7	7,075.7
Harwich	65.4	12.6	-	-	-	-	0.8	-	-	71.7	150.5	442.5
Mashpee	100.1	-	-	-	-	-	14.6	-	-	-	114.7	337.2
Orleans	-	-	-	-	-	-	-	-	-	-	-	-
Provincetown	-	-	-	-	-	-	-	-	-	-	-	-
Yarmouth	220.8	-	-	-	-	-	2.4	-	-	-	223.2	656.2
<u>Mount Hope Bay</u>												
Fall River	-	-	-	-	-	-	-	-	-	-	-	-
Somerset	-	-	-	-	-	-	-	-	-	-	-	-
Swansea	-	-	-	-	-	-	-	-	-	-	-	-
<u>Narragansett Bay</u>												
Assonet - Freetown	-	-	-	-	-	-	-	-	-	-	-	-
Berkley	-	-	-	-	-	-	-	-	-	-	-	-
Dighton	-	-	-	-	-	-	-	-	-	-	-	-

TABLE VI (Cont.)  
RECURRING TIDAL FLOOD DAMAGES FOR THE 1954 HURRICANE  
ALONG MASSACHUSETTS COASTAL AND TIDAL AREAS  
(Thousands of Dollars)

Location	(1) Residential	(2) Commercial	(3) Public	(4) Urban	(5) Industrial	(6) Railroad	(7) Highway	(8) Transportation Other	(9) Utility	(10) Unspecified	1956 Price Level Total	1977 Price Level Total
Offshore Islands												
Nantucket	149.0	23.1	-	-	-	-	-	-	-	6.5	178.6	525.1
Martha's Vineyard												
Chilmark	-	8.7	-	-	-	-	59.0	-	-	23.3	91.0	267.5
Edgartown	77.4	66.2	-	-	-	-	-	-	-	59.7	203.3	597.7
Oak Bluffs	59.7	23.4	-	-	-	-	-	-	-	2.9	86.0	252.8
Tisbury-Vineyard	10.8	104.4	-	-	-	-	-	-	-	6.2	121.4	356.9
Totals	10,842.4	3,184.6	644.6	10.0	1,704.1	129.0	119.6	215.6	-	4,689.8	21,539.7	63,326.7

FOOTNOTES

- (1) Damages to or loss of houses and associated property (e.g. yards, garages, furniture, etc.).
- (2) Damages to or loss of retail stores and businesses such as department stores and restaurants.
- (3) Damages to or loss of public property such as government buildings, parks, memorials, wharfs, piers, seawalls, bulkheads, etc.
- (4) Damages to or loss of residential, commercial and public property in urban areas not included in the previous three categories.
- (5) Damages to or loss of industrial property such as factories and related grounds, offices and machinery.
- (6) Damages to or loss of railroad tracks, trains, cars, stations and other properties.
- (7) Damages to or loss of roadways, bridges, etc.
- (8) Damages to or loss of transportation facilities. May include damages to railroads, highways, ships, ports, etc.
- (9) Damages to or loss of utilities such as water and power.
- (10) May include damages in any of the preceeding categories as well as other miscellaneous losses.

### September 1960 Hurricane

Hurricane "Donna" was the fourth most devastating and also the most recent of the major hurricanes which will be discussed in this report. "Donna", which passed through the New England area on the 12th and 13th of September 1960, formed in the Caribbean on September 2, and traveled westward, passing to the north of Puerto Rico, the Dominican Republic and Cuba. Turning northward through the Florida keys it moved up the center of Florida and eastward across the coast south of Jacksonville on September 11th. It then closely paralleled the coast and at 8:00 a.m. on the 12th was about 65 miles southeast of Cape May, New Jersey. As the storm moved up the coast to Long Island its eye widened into an east-west oval, stretching 125 miles from Montauk Point of the eastern tip of Long Island to the Battery at New York City. The center moved inland near Bridgeport, Connecticut, shortly after 4:00 P.M. As the storm progressed northward over New England the east-west oval turned into a north-south oval. At 6:30 p.m. the eye of the storm passed over Worcester, Massachusetts and reached southern New Hampshire at 7:30 p.m. The center of the storm passed to the west of Maine's major cities, over the eastern tip of Lake Sebago. As it moved over the land on its course through central New England it rapidly weakened and blew itself out over the Gulf of St. Lawrence. (See Plate No. 2.)

Winds of 100 m.p.h. were reported along the Connecticut shore. A gust of 140 m.p.h. was reported at the Blue Hills Observatory south of Boston, Massachusetts, at 5:56 p.m. Block Island, Rhode Island, reported gusts of 125 m.p.h. The heaviest gust of wind at New Bedford, Massachusetts, occurred at 4:23 p.m. and was reported to be 93 m.p.h. Winds up to 75 m.p.h. were reported at Concord, New Hampshire and Portland, Maine.

Three fatalities were more or less directly attributed to the hurricane, all in eastern Massachusetts. Nearly half of the total damage caused by the storm occurred in coastal areas, including a few cottages, hundreds of boats, fishing and lobstering gear, coastal land and seawalls (by erosion), and trees, limbs and utility lines. Wind damage was most concentrated east of the low pressure center path and included some direct structural damage, largely limited to damage to roofs, chimneys, antennae and some windows. However, most damage was from falling trees and limbs, which in turn toppled utility poles and lines and damaged buildings and automobiles. On Cape Cod numerous families were without service for several days, despite heroic efforts by repair crews. Tides of from 5 to 10 feet above normal occurred along the southern coastal area of Massachusetts but tidal damage was minimal in comparison to the previous discussed hurricanes since the highest storm surge from "Donna" did not coincide with the time of the astronomical high tide.

The New England Division of the U.S. Army Corps of Engineers prepared a post-flood report for hurricane "Donna". The figures shown in Table VII

reflect the damages that were experienced along the Massachusetts coastline as a result of the storm and were taken from the report. In addition, figures are shown updated to 1977 price levels to reflect the effect of inflation that has occurred over the 17-year period.

TABLE VII  
EXPERIENCED TIDAL FLOOD DAMAGES FOR THE 1960 HURRICANE ALONG  
MASSACHUSETTS COASTAL AND TIDAL AREAS  
(Thousands of Dollars)

<u>LOCATION</u>	<u>1960 PRICE LEVELS</u>	<u>1977 PRICE LEVELS</u>	<u>REMARKS</u>
<u>Buzzards Bay Area</u>			
Dartmouth	35.0	91.0	A major portion of the losses were a result of damages to boats, wharves, piers, summer homes, cottages, beaches and roadways.
Fairhaven	70.0	182.0	
Marion	180.0	468.0	
Mattapoisett	85.0	221.0	
New Bedford	1,400.0	3,640.0	
Wareham	720.0	1,872.0	
Westport	25.0	65.0	
<u>Cape Cod Area</u>			
Barnstable	150.0	390.0	The major portion of the losses were as a result of damages to boats, ducks, piers, wharves, homes, commercial establishments, roadways and beach erosion.
Bourne	140.0	364.0	
Chatham	30.0	78.0	
Dennis	50.0	130.0	
Falmouth	700.0	1,820.0	
Harwich	50.0	130.0	
Mashpee	10.0	26.0	
Yarmouth	100.0	260.0	
Orleans to Provincetown	500.0	1,300.0	
<u>Mount Hope Bay</u>			
Fall River & Swansea	25.0	65.0	Most losses due to damage to homes.
<u>Cape Cod Canal North to New Hampshire</u>	300.0	780.0	Losses due mainly to boats and some docks.
<u>Other Miscellaneous</u>			
Coastal Storm Damage	130.0	338.0	Damages suffered mainly by fishing industry.
<b>TOTALS</b>	<u>4,700.0</u>	<u>12,220.0</u>	

### Northeaster of 26 December 1909

The morning tide of December 16, 1909, attending the severe storm of the same date on the New England Coast, was one of the highest ever recorded in Boston.

At Boston Light the predicted time of high tide was 10:30 a.m. The wind from late afternoon of the 25th until nearly noon of the 26th, was from the east and northeast over Boston Harbor and Massachusetts Bay, rapidly increasing in force during the evening of the 25th to very high velocities soon after midnight and continuing undiminished through the day of the 26th.

At Cape Cod, Highland Light, the wind velocity at 8 a.m. of the 26th was 48 m.p.h. from the northeast; at noon - 72 m.p.h.; at 2:15 p.m. - 84 m.p.h.; and at 5 p.m. - 66 m.p.h. all from the east-northeast. At midnight it was 60 m.p.h. from the north. At Boston the hourly movements from midnight to noon of the 26th ranged between 25 and 39 m.p.h. The hourly maximum rate was between 32 and 45 m.p.h., the latter occurring at 5:10 a.m., from the northeast.

The increasing high wind occurring with the rising tide, together with a high run of tide, caused the water in Boston Harbor to reach approximately the record height of the tide of April 14, 1851 (The Lighthouse Storm), which at the U.S. Navy Yard was 15.0 to 15.1 feet above m.l.w. The height of the tide of December 26, 1906, at the same station was 14.98 feet above m.l.w. In general, the tide in Boston Harbor and Massachusetts Bay was approximately 3.5 feet above the predicted height. The actual heights as recorded by the U.S. Corps of Engineers and other reliable authorities at the following places was:

<u>Location</u>	<u>Stillwater Tidal Elevations in Feet Above Mean Low Water</u>
Black Rock Wharf, Newburyport Harbor	12.68'
Sandy Bay, Rockport Harbor	13.64'
Boston Harbor, Deer Island	14.56'
Plymouth Harbor	14.80'
Barnstable Bay	13.25'
Provincetown Harbor	14.35'

The tide at all these stations with the exception of Plymouth and Barnstable was approximately 5 feet above mean high water. Plum Island, Newburyport, reported that the surf broke over the island at the valley locations and also flooded wells for the homes. Coastal flooding was evident from Plymouth, Massachusetts northward with severe flooding in areas of Weymouth and Hull. Most of the damage from the storm was confined to coastal areas with hundreds of small craft destroyed, several large ships beached or sunk and numerous wharves, houses and other beachfront structures damaged or destroyed.

Unfortunately, there is no detailed storm damage information available in the Corps files for this storm.

#### Northeaster of 29 December 1959

On December 29th, 1959 easterly gales from a storm center at sea pushed sea water in a "storm surge" to produce extremely high tide levels along part of the New England coast with full eastern exposure. Though not a record storm surge, its timing on the morning of the 29th coincided with one of the highest normal spring tides of the year. The combination brought a high tide of 14.4 feet above mean low water at Boston. This tide was the highest recorded at Boston in over 50 years and flooded waterfront streets in Boston and coastal suburbs. A local high tide level of 16.0 feet above m.l.w. was observed in a small area of Chelsea, Massachusetts. In vulnerable areas along the central Massachusetts coast, seawalls were topped by wave action or tide, coastal roads and causeways were flooded or piled with wave tossed rocks, beaches were disfigured, boats were battered, and many lobster traps were lost. The greatest concentration of damage was at Hull, which was declared a disaster area. In one section of Hull, water rose six feet deep in the streets, held in by the seawalls intended to keep out high seas. Fifteen hundred people were forced to leave their homes. The storm also produced heavy snowfall on inland areas, ranging from 8 to 18 inches with scattered areas of glaze and sleet. The weight of ice and snow accumulation felled a number of trees, branches, and wires.

The New England Division of the U.S. Army Corps of Engineers prepared a resume report for this storm. Figures in Table VIII taken from the report reflect the damages that were experienced along the Massachusetts coastline as a result of the storm. In addition, this table shows figures updated to 1977 price levels to reflect the effects of inflation that has occurred over the 18-year period.

TABLE VIII  
EXPERIENCED TIDAL FLOOD DAMAGES FOR THE  
29 DECEMBER 1959 NORTHEAST STORM ALONG  
MASSACHUSETTS COASTAL AND TIDAL AREAS  
(Thousands of Dollars)

<u>Location</u>	<u>1959 Price Levels</u>	<u>1977 Price Levels</u>	<u>Remarks</u>
Boston	1,000.0	2,600.0	During the course of the storm the high tide and wave action caused an extensive amount of damage to and in some instances loss of structures, land and facilities. Most of the losses can be attributed to damage of residential dwellings, commercial establishments, roadways, seawalls, wharves, piers, automobiles, schools, boats, beach material.
Braintree	1.0	2.6	
Cape Cod	100.0	260.0	
Chelsea	10.0	26.0	
Cohasset	5.0	13.0	
Duxbury	25.0	65.0	
Gloucester	10.0	26.0	
Hingham	5.0	13.0	
Hull	930.0	2,418.0	
Lynn	100.0	520.0	
Marblehead	50.0	130.0	
Marshfield	110.0	286.0	
Nahant	100.0	260.0	
Newburyport	15.0	39.0	
Plymouth	20.0	52.0	
Quincy	750.0	1,950.0	
Revere	1,000.0	2,600.0	
Salisbury	100.0	260.0	
Saugus	100.0	260.0	
Scituate	290.0	754.0	
Swampscott	5.0	13.0	
Weymouth	70.0	182.0	
Winthrop	250.0	650.0	
Other	54.0	140.4	
Totals	5,200.0	13,520.0	

### Northeaster of 19-20 January 1961

On January 19-20, 1961 a major snowstorm brought paralyzing blizzard conditions to parts of southern New England. True blizzard conditions are rare in this area, making this storm all the more remarkable since it was the second such storm of the season. The cause was a low pressure center whose origin traced back to a severe storm which had battered the Washington - Oregon coast on January 17. Passing over most of the nation as a weak low pressure center, it approached the east coast just to the south of Washington, DC, and intensified almost "explosively" in that area, then continued on and intensified more as it traveled northeastward well off the New England coast toward the Canadian Maritime Province.

Blizzard conditions, with temperatures to lower than 10°F, gale force winds at times and very poor visibility in snow and blowing snow plagued much of the area. At Nantucket the greatest wind speed averaged 48 m.p.h., with peak gusts of 60 m.p.h. recorded at Blue Hill observatory and 46 m.p.h. at Boston, Massachusetts. Snow drifts of 4 to 5 feet were common and drifts exceeding 15 feet were reported at several locations.

Strong winds produced very high storm tides along the coast. These reached 4.5 feet above normal at Nantucket, where flooding of some homes in low areas near the harbor occurred, and tides of 8.8 above msl were recorded in Boston. The most serious flooding episode was at Hull where 300 persons had to be evacuated, mostly by boat. Sea water in the affected area filled home basements and then froze, hampering cleanup efforts. In all, about 400 persons were evacuated in Massachusetts. Several popular Cape Cod beach areas were badly eroded by the storm action. Some homes and buildings were destroyed or washed away. The coastal area most affected was from Boston southward around the bay side of Cape Cod. Some cranberry bogs were damaged by salt water inundation.

Corps personnel visited numerous sites damaged by the storm along the Massachusetts coastline and collected data from local officials and private property owners concerning the damages sustained by them. Since no comprehensive damage survey study or report was prepared on the storm by the Corps, no detailed breakdown of damages is available in its files. However, based on the damage survey report prepared by the Corps for the northeaster of 29 December 1959 and information obtained from various sources it was estimated that the storm caused a total of about \$10,000,000 in damages along the Massachusetts coastline.

### Northeaster of 19-20 February 1972

The northeast storm of 19 and 20 February 1972 developed in New England as a deep low pressure center, moved northeastward at about 25 m.p.h. offshore, passing over the outer Cape Cod during the 19th and passing on into the Gulf of Maine early on the 20th. High winds accompanied the storm with gusts of 90 m.p.h. recorded at the Portland lightship. Velocities were not so great at far inland stations though many cases of minor structural damage occurred and fallen trees and limbs caused extensive utility outages. Devastation along the coast was far greater, however, from storm surge tides of 2 to 4.5 feet above the normally high coincident spring tides, plus the action of exceptionally high breakers and surf. Coastal sections of Massachusetts were declared official disaster areas, with damages in the millions of dollars. Many thousands of homes and other shore buildings were damaged and many were completely demolished or swept into the sea. The greatest impact was from Plymouth, Massachusetts northward to Portland, Maine, where this storm was said to be the worst in 75 years. The sea tossed 8-ton concrete seawall blocks about as if they were ping pong balls. Stones were hurled into buildings and large sections of roads and sidewalks were washed away. Many formerly sandy beaches were left a mass of boulders. There were many cases of severe coastal flooding, with Essex, Massachusetts reporting the worst flooding in the towns history. Precipitation was mostly rain along the coast ranging from 1 to 3 inches. Heavy snow up to 20 inches in depth fell over the Worcester County, Massachusetts area. Snow clogged major highways and hampered traffic on them for a number of days afterwards. The storm reached true blizzard proportions in the northern sections of New England and at times at the higher elevations in the southern areas, with high wind, frigid air and low visibility from blowing snow and sleet.

As a result of the storm, several coastal counties in Massachusetts were declared disaster areas by the President making them eligible for financial assistance from the federal government. At that time the Office of Emergency Preparedness requested the Corps to assist them in preparing damage survey reports for the public sector. Table IX shows the results of the surveys in the affected communities. These figures reflect only an estimate of the damages suffered by public property and facilities in these communities; they do not include any damages to private property and structures. It was estimated that the damages inflicted on the private sector were two to three times more than those experienced by the public sector. Table IX also gives an update of these figures to 1977 price levels to account for the effects of inflation which has occurred over this five year time frame.

TABLE IX  
EXPERIENCED TIDAL FLOOD DAMAGE TO  
PUBLIC FACILITIES FOR THE 19-20 FEBRUARY 1972  
NORTHEAST STORM ALONG MASSACHUSETTS COASTAL  
AND TIDAL AREAS  
(Thousands of Dollars)

<u>Location</u>	<u>1972 Price Levels</u>	<u>1977 Price Levels</u>	<u>Remarks</u>
Beverly	13.7	20.6	During the course of the storm the tidal surge and wave action caused an extensive amount of damage to public property and facilities. Most of the damages occurred to riprap revetment structures, seawalls, sand dunes, beaches, groins, breakwaters, boatramps, piers, fences, buildings, roadways, boats and transportation facilities.
Boston	960.0	1,440.0	
Cohasset	29.4	44.1	
Gloucester	436.6	654.9	
Hull	759.5	1,139.2	
Ipswich	14.3	21.4	
Manchester	59.6	89.4	
Marblehead	47.2	70.8	
Marshfield	250.2	375.3	
Nahant	398.1	597.2	
Nantasket	160.0	240.0	
Newbury	1.1	1.6	
Newburyport	14.0	21.0	
Plymouth	32.1	48.2	
Quincy	71.8	107.7	
Revere	1,097.5	1,646.2	
Rockport	24.8	37.2	
Salem	80.1	120.2	
Salisbury	15.5	23.2	
Scituate	1,273.3	1,910.0	
Swampscott	71.0	106.5	
Weymouth	126.0	189.0	
Winthrop	174.8	262.2	
Totals	<u>6,110.6</u>	<u>9,165.9</u>	

# *PART III*

## *THE CORPS ROLE IN BEACH EROSION*

### *CONTROL AND HURRICANE*

### *PROTECTION*

#### *General*

Beach and shore erosion is one of the nation's pressing problems. The United States' shorelines, including those of the Great Lakes total about 94,000 miles. At present, 75 percent of the population of the United States lives in states bordering on the oceans and Great Lakes; and 12 of our 13 largest cities are located in the coastal zone. The unrelenting pressures generated by this growing population and its demand for shore land for homes, industries, transportation terminals, recreation and marine foods quicken interest and concern in the protection and restoration of beaches and shores. This interest and concern has led to increasing federal involvement in shore protection, which has been paralleled by expanding interest on the part of the coastal states and increasing involvement of the Corps of Engineers.

Over the years the Corps has been charged with the study of publicly-owned shore areas, with proportional amounts of expenses for the study and any resulting construction shared by the federal government and the state or local interest involved. In 1956, the authority was broadened to include the protection of private property if such protection was incidental to the protection of publicly-owned shores, or if such protection would result in public benefits. By 1962, the federal role had expanded to include a larger proportion of the cost of construction and the total cost of the study.

Hurricane protection is closely related to shore erosion control and protection. In view of the severe damages sustained from hurricanes along the eastern and southern coastal areas of the United States, the 84th Congress, 1st Session, adopted Public Law No. 71 on 15 June 1955, which reads as follows:

"Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That in view of the severe damage to the coastal and tidal areas of the eastern and southern United States from the occurrence of hurricanes, particularly the hurricanes of August 31, 1954, and September 11, 1954, in the New England, New York, and New Jersey coastal and tidal areas, and the hurricane of October 15, 1954, in the coastal and tidal areas extending south to South Carolina, and in view of the damages caused by other hurricanes in the past, the Secretary of the Army, in cooperation with the Secretary of Commerce and other Federal agencies concerned with hurricanes, is hereby authorized and directed to cause an examination and survey to be made of the eastern and southern seaboard of the United States with respect to hurricanes, with particular reference to areas where severe damages have occurred.

"Sec. 2. Such survey, to be made under the direction of the Chief of Engineers, shall include the securing of data on the behavior and frequency of hurricanes, and the determination of methods of forecasting their paths and improving warning services, and of possible means of preventing loss of human lives and damages to property, with due consideration of the economics of proposed breakwaters, seawalls, dikes, dams, and other structures, warning services, or other measures which might be required."

This led to improved hurricane forecasting and warning services and to authorization for the construction by the Corps of projects for hurricane protection. In 1958 the 85th Congress passed Public Law 874 which authorized the federal government to pay 70 percent of the total first cost of these hurricane protection projects.

In many instances, broad comprehensive planning has been responsible for the development of multi-purpose projects providing shore protection, beach restoration, and hurricane protection while also benefiting public recreation, navigation and protecting and preserving fish and wildlife.

By various legislative actions, Congress has directed the Chief of Engineers to carry out the policies and programs established to protect and restore the nation's shorelines. Under these legislative guidelines, the Corps of Engineers performs research on the causes of beach erosion and, after investigating and studying specific shore and beach erosion problems, constructs or, in certain cases, reimburses local and state governments for constructing projects which have been authorized for federal participation.

## RESEARCH

The Coastal Engineering Research Center, a branch of the Corps of Engineers, develops in depth research investigations of shore processes, storm frequencies, and storm-tide elevations. Staffing by a host of engineers, scientists, and planners working in conjunction with universities and private research organizations has made it one of the foremost beach erosion research centers in the United States. The research program is the base on which the planning and construction programs depend. Without research, the effectiveness of completed projects might be uncertain and costly overdesign or failure might be common.

## CORPS OF ENGINEERS PROGRAMS

Shore protection and beach restoration projects, for this discussion, will be grouped in two programs - one consisting of projects specifically and individually authorized by Congress and the second consisting of projects for which individual authorization by Congress is not required. The latter program includes projects for which the federal share of the construction cost will not exceed one million dollars. Hereafter in this discussion these programs will be referred to as the regular project program and the small project program, respectively. In addition, if the erosion is attributable to federal navigation works, mitigating measures costing not more than one million dollars can be constructed entirely at federal expense and without specific Congressional authorization.

## PROJECT DEVELOPMENT

Shore protection and beach restoration projects begin with a local request for help. Any person or group of persons desiring assistance in combating beach erosion can obtain information and advice from any Corps of Engineers District or Division office. Eroded publicly owned shores and shores eroded because of federal navigation works are eligible for federal assistance; privately owned shores may be eligible for federal assistance if there is a public benefit such as that arising from public use. People desiring assistance in combating beach erosion can usually act most effectively through and in cooperation with the state, county, or city agency concerned with beach and shore use and management. The agency, in turn, can reinforce its effectiveness by early consultation with the appropriate District or Division Engineer to explore any question of eligibility and applicability for the small project program, or the program for mitigating erosion caused by federal navigation works. If either of these programs is applicable, the Secretary of the Army can authorize a beach erosion study at the request of the responsible local agency.

Beach erosion studies for the regular project program must be individually authorized by Congress. The District or Division Engineer will begin the study as soon as the necessary authorization and funds are provided. Normally, the local interests sponsoring the study and the District or Division Engineer responsible for its prosecution will continue consultations, exchange information, and make plans for conducting the study while the authorization and fund allocation actions are in progress.

The investigation and study are intended to determine whether a federal project is justified and, if so, whether its construction is feasible. Throughout the study, public meetings are held to obtain the views, opinions, desires and needs of the local parties involved.

Environmental, social and historical aspects of the project are reviewed during the course of the study to determine the resultant impact if any on the area if the project is adopted. Considerable time is spent developing and reviewing all these considerations and proposals which are incorporated within the final project to decrease or eliminate any encroachment upon these aspects. Environmental considerations are becoming more and more important in order to insure that a project is not constructed that will degrade or debase the environment. The future of America depends upon the judicious balancing of controlled growth on one hand and our precious environment on the other. It is to this end that the Corps and our society has become increasingly concerned with the protection of our natural resources and historical past.

The authorities and regulations under which the Corps of Engineers operate, require that the annual benefits to the public as a result of construction of the project must outweigh the annual cost associated with the project. This benefit-cost ratio must be equal to or greater than 1.0 to justify federal participation and cost-sharing in a project. The amount of benefits and costs are determined by an economic analysis during the course of the study.

The estimated first cost of a project usually is based on the cost of materials for construction, contingencies, engineering, design, supervision and administration. This estimated first cost is then used to establish the annual charges which would be incurred if the project was constructed. The annual charges are computed by spreading the first cost over an established project life (usually 50 years) using a directed interest and amortization rate and adding to this the cost of any anticipated maintenance such as may be necessary for a protective structure or periodic sand nourishment.

Benefits for a beach erosion control project are mainly derived from two areas, namely prevention of damages, both direct and indirect, and recreational benefits from increased use of the additional beach area provided when a sandfill project is recommended. Prevention of direct damages is associated with prevention of loss of land and damage to residences, commercial establishments, roadways, parking areas, seawalls, groins, bathing facilities, etc. in the proposed project area. Indirect damages are those that evolve as a result of the initial direct damages. Recreational benefits are those derived from an estimated per capita dollar increase in use of the beach after a sandfill project is constructed. The combined benefits are also annualized to establish the estimated annual benefits which maybe expected to occur as a result of project construction. Intangible benefits such as enhancement of property values and the improved social well-being of the people in the area due to the increased protection which is afforded by construction of a project will also be derived. But, it is impossible to place a monetary value on such benefits. Only the tangible benefits associated with a project are included in developing the benefit/cost ratio but it should be kept in mind that intangible benefits will also be derived.

The annual benefits are then compared to the annual costs. If the ratio of the annual benefits to the annual costs equals or exceeds 1.0 the project is usually considered to have sufficient merit to warrant federal participation and cost-sharing.

In the case of Congressionally authorized studies the completed feasibility report including the recommendations by the Division Engineer is reviewed by the Office of the Chief of Engineers and the Board of Engineers for Rivers and Harbors before it is sent to Congress for eventual adoption and authorization if the report is favorable to federal participation. For non-Congressionally authorized studies the reports are reviewed and if favorable funded by authority of the Chief of Engineers Office.

Funding of projects which are authorized by Congress for construction is considered annually by Congress as it formulates the annual appropriations bill. As soon as funds are appropriated, either the Corps or the sponsoring agency develop detailed plans and specifications for the project. After which time the project is put out to bids to contractors who are interested in doing the work. Normally the low bidder on the job is awarded the contract to do the work. During the course of construction the District or Division Engineer continues to consult and coordinate all activities with the local sponsoring agency. If the local sponsoring agency has the responsibility of developing the plans and specifications, awarding the contract and monitoring the construction work the District or Division Engineer gives assistance as required and monitors

all facets of the work. Upon completion, the protective works are turned over to the sponsoring local interests for operation and maintenance in accordance with the authorizing legislation.

The state or political subdivision faced with shore protection and beach restoration problems usually selects one of its agencies to represent local interests and cooperate with the Corps of Engineers in the conduct of these studies and project construction if feasible. In many cases, this same agency operates and maintains the completed project.

### LOCAL COOPERATION

The legislation establishing the federal shore protection and beach restoration programs declares it to be the "Policy of the United States to assist in the construction, but not maintenance, of works for the improvement and protection against erosion by waves and currents of the shores of the United States, its territories and possessions." The legislation spells out the conditions and limits of federal participation. Basically, it relates federal participation to public benefit and requires the active participation of the sponsoring local interests. The costs allocated to the restoration and protection of federal property, however, are borne fully by the federal government. Federal cost sharing may be up to one-half the cost of protecting shores owned by non-federal public agencies. Protection of shores not publicly-owned may be eligible for federal cost sharing up to one-half of the initial project cost provided there is significant public benefit arising from public use or from protection of nearby public facilities and provided such work is economically justified. The federal cost share is adjusted in accordance with the degree of such benefits. Under certain conditions, a project involved with the restoration and protection of state or other publicly-owned shore areas associated with a park or other such conservation area maybe eligible for federal cost sharing of up to 70 percent of the total project cost, exclusive of land costs. In order to be eligible for 70 percent federal funding such areas must include a zone which excludes permanent human habitation, including summer residences; provide for conservation, preservation and development of the natural resources of the environment; extend landward a sufficient distance to include protective dunes, bluffs or other natural features which serve to protect the uplands from damage; and provide essentially full park facilities for appropriate public use.

In cases where the project involves sandfill for the creation of an artificial barrier beach and the study has determined that periodic sand nourishment is the most efficient and economic means of maintaining the beach this periodic nourishment maybe considered as part of the

initial construction cost and is eligible for federal cost sharing in the same proportion as that for the first cost of the project. Section 215 of Public Law 90-483 permits local interests to expedite construction of authorized projects for which federal funds are not immediately available. The local interests would be required to pay for the full cost of constructing the project and they would then be reimbursed for the federal share by the U.S. Government when funds become available.

Before any project can be constructed, formal assurances of local cooperation have to be furnished by the local sponsoring agency. The local sponsor must be a municipality or public agency fully authorized under state laws to give such assurances and financially capable of fulfilling all measures of local cooperation. The sponsoring agency must normally agree to:

1. Contribute in cash the local share of project construction cost and in the case of projects not requiring Congressional authorization and funding, assume full responsibility for all project costs in excess of the federal cost limitation of \$1,000,000.
2. Provide without cost to the United States all necessary lands, easements, and rights-of-ways.
3. Hold and save the United States free from claims for damages which may result from construction and subsequent maintenance of the project.
4. Assure that water pollution that would affect the health of bathers will not be permitted (applied only in cases where the beach is used for recreational purposes).
5. Assure continued public ownership or continued public use of the shore upon which the amount of federal participation is based, and its administration for public use during the economic life of the project.
6. Assure maintenance and repair, and local share of periodic beach nourishment where applicable, during the useful life of the works as required to serve the project's intended purpose.
7. Provide and maintain necessary access roads, parking areas and other public use facilities open and available to all on equal terms.

Specific cases may also warrant assigning other additional local responsibilities, such as providing appurtenant facilities required for realization of recreational benefits.

Appendix C contains a copy of the various Public Laws by which Congress has directed the Chief of Engineers to carry out the policies and programs established by them to protect and restore the Nation's shorelines.

## *Corps Projects*

The New England Division of the U.S. Army Corps of Engineers has conducted several beach erosion control and hurricane protection studies along the Massachusetts coastline. As a result of these studies, seven federal beach erosion control projects have been partially or completely constructed, while eight other projects have been authorized for federal participation but, have not been constructed. In addition, a hurricane protection project has been constructed, and a second was authorized for construction but has since been deauthorized. The following pages contain a description and discussion of these projects.

### CONSTRUCTED BEACH EROSION CONTROL PROJECTS

#### PLUM ISLAND BEACH NEWBURY, MASSACHUSETTS

Several beach erosion control studies of the Plum Island shoreline have been conducted by the New England Division of the United States Army Corps of Engineers both in cooperation with and at the request of the Commonwealth of Massachusetts, as well as at the request of local interests. The first of these studies was completed in August 1952, and the latest in December 1976. Three other studies were made and reports prepared for areas along the Plum Island shoreline in 1967, 1969, and 1973. Of these studies, that of 1973 was the only one which resulted in the adoption and construction of a federal beach erosion control project. Its results are contained in the detailed project report entitled "Plum Island Beach, Newbury, Massachusetts", and are discussed in the following pages.

The shoreline of Plum Island is approximately 8 miles in length, and consists of a sandy coastal barrier bar largely covered with dunes along the southern two thirds of the island. The northern one-third of the island, within the limits of the city of Newburyport and the town of Newbury, has commercial and residential development.

At the time of the study residential and commercial property, a parking area and a highway accounted for the principal development directly behind the beach and seaward of the shorefront road. During the summer season the beach sees extensive use by local residents and tourists who visit the area.

The location and exposure of the beach makes it susceptible to erosion by wave, wind tidal and current action in the area, especially during northeast storms. This has resulted in the gradual landward recession of the shoreline, the lowering of the beach berm, and the loss of beach material. The immediate problem addressed in the study was the 800 foot sector of shoreline at the town parking lot and extending north from there fronting Northern Boulevard. This area is shown on the attached project map at end of this section.

The near record northeast storm of 19 February 1972, destroyed the wide fronting beach, the backlying dunes, and one cottage in this area. Two other cottages were seriously damaged, and another two were moved inland to the maximum extent possible to get them out of immediate danger. With the destruction of the backshore dunes which represented the last line of natural defense, the area was left vulnerable to a major breakthrough which could have proved disastrous to the island, possibly cutting through the Plum Island Turnpike which is the island's sole link with the mainland.

In view of the recreational nature of the area, the increasing demand for additional saltwater bathing areas and the availability of suitable sandfill within a short distance of the beach, the study determined the most practical method of correcting the erosion problem would be beach restoration.

The plan of protection and improvement which was developed in the report and is shown on the project map at the end of this section, consisted of dune restoration and embankment reinforcement along 800 feet of backshore fronted by a protective level beach berm 75 feet in width at an elevation of 15 feet above mean low water. This work was to be accomplished by the direct placement of suitable sandfill. The top of the dune would correspond in elevation to the general embankment and stable dune elevations in the area. The project would provide a protective beach width of about 210 feet in front of the existing backshore.

An economic analysis was performed during the course of the study to determine the first cost, annual charges, benefits, and benefit-cost ratio associated with the recommended plan.

At the time of the study, the estimated first cost of the recommended plan was \$200,000. This figure was based on the cost of 35,000 cubic yards of sandfill with allowances for contingencies, engineering, design, supervision, and administration. The annual charges associated with the estimated first cost of the recommended plan were found to be \$26,800 based on a project life of 50 years, a directed interest rate of 5½% and provisions for 3,000 cubic yards of sandfill for annual beach nourishment.

The estimated annual benefits that could be attributed to the construction of the improvement project would be derived from prevention of damages to the existing structures and the development backing the beach, and the increased recreational use of the beach. Other benefits such as prevention of indirect damages and increased property values brought about by added protection would also result if the project were built.

The recreational benefits were evaluated as both general and local public benefits, and on an annual basis were found to amount to a net benefit of \$43,700. In addition to the recreational benefits, \$2,000 worth of annual maintenance and repair costs would be eliminated if the project were constructed and \$1,900 worth of land would be kept from being lost each year. The total tangible benefits which could be attributed to the project were found to be \$47,600. In addition to these benefits, it was believed a very strong intangible benefit would be realized, as a result of the projects preventing extensive potential losses that would occur to properties if the barrier beach was breached.

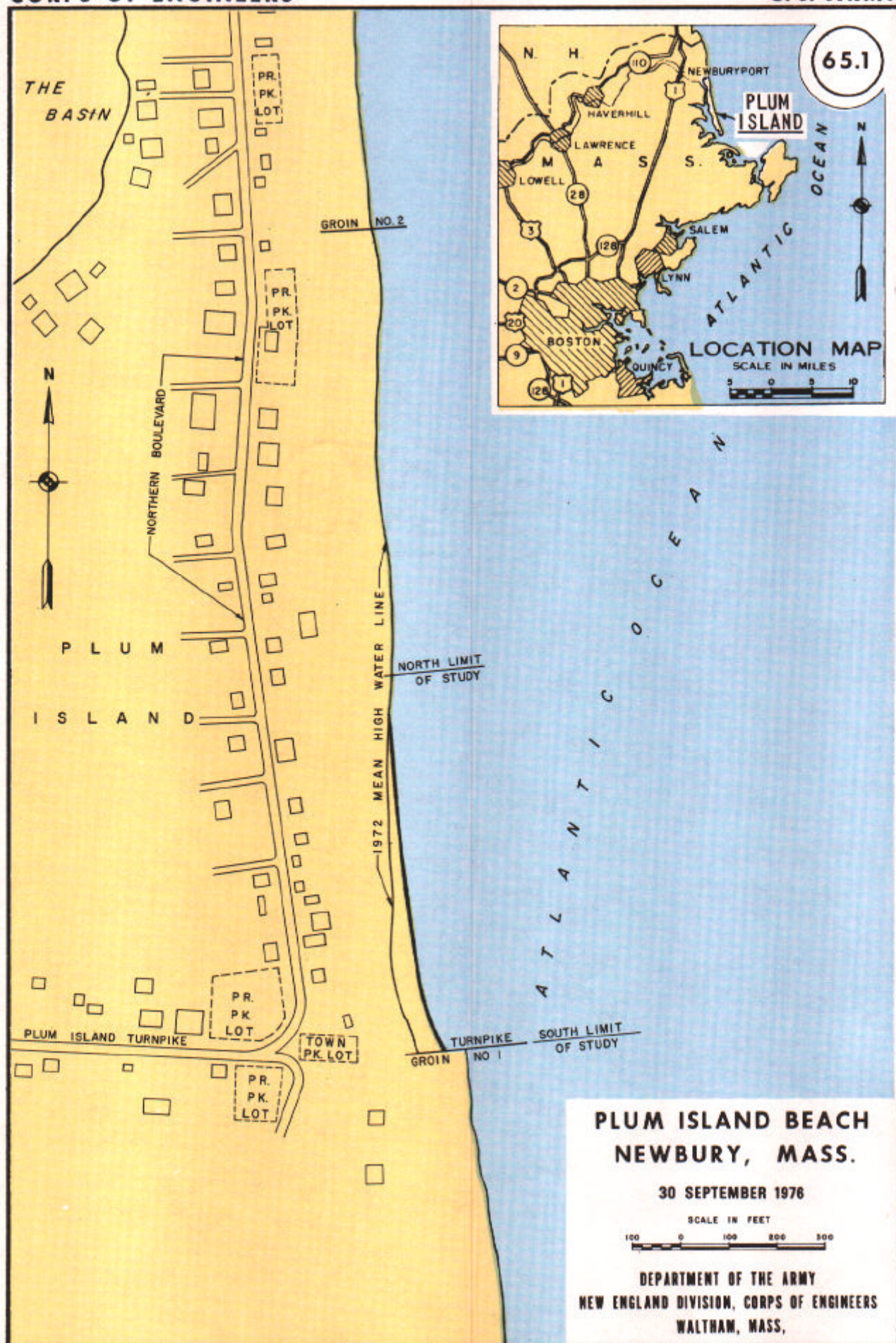
The ratio of the estimated annual benefits to the estimated annual costs was found to be 1.8 indicating economic justification for federal participation in the construction of a beach erosion control project at Plum Island Beach.

Based on the study findings the Division Engineer recommended in the report that the beach erosion project be authorized for Plum Island Beach under the provisions of Section 103 of the River and Harbor Act of 1962, as amended.

The project was adopted by the Office of the Chief of Engineers on 1 February 1973, as recommended in the report. The project provided for federal participation in the amount of 50 percent of the first cost of construction in the plan of protection involving restoring the dune, strengthening the embankment and widening the beach by direct placement of suitable sandfill for a length of 800 feet northerly from the turnpike groin. The project also provided for 50 percent federal participation in the cost of periodic nourishment for the first 10 years of the project life.

Work was initiated on the project in February 1973, and completed in April of the same year at a total cost of \$212,297 including local contributions totaling \$99,151. The first cost of the project included \$194,294.40 for 43,760 cubic yards of sandfill. The fill material was dredged from the channel at the mouth of the Merrimack River, stockpiled on the south bank of the river and truck hauled to the project site.

Since its construction the project has been very effective in serving its intended purpose. The beach area is being used intensively during the summer season for bathing activity and the backshore development has been protected against wave action and flood damage in the project area. The artificially placed beach fill has remained stable, and some naturally occurring accretion has been noted in the project area. No periodic nourishment has been needed for the beach since project construction.



WINTHROP BEACH, MASSACHUSETTS  
BEACH EROSION CONTROL STUDY

In a formal application on 9 August 1945 the Metropolitan District Commission of the Commonwealth of Massachusetts requested a cooperative study of beach problems within the Metropolitan District of Boston, Massachusetts including Lynn Shore, Winthrop, Revere Beach, Quincy Shore and Nantasket and providing for prosecution jointly by the Metropolitan District Commission and the United States. This request was approved by the Chief of Engineers, United States Army, 2 October 1945, in accordance with the authority conferred by the provisions of Section 2 of the River and Harbor Act approved 3 July 1930 and Public Law 166, Seventy-ninth Congress, approved 31 July 1945.

At the further request of the Metropolitan District Commission (MDC) the study of Winthrop Beach was given priority to permit its completion prior to completion of the final report on the entire study.

The Commonwealth of Massachusetts, through the Metropolitan District Commission agreed to contribute one-half of the cost of the study. The field work and collection of basic data for the study was carried out by the Corps of Engineers, under the supervision of the Division Engineer. An interim report, completed by the Beach Erosion Board on 6 August 1946, was furnished to the MDC for use in planning protective works which at that time were partially under construction. The final report was completed by the Beach Erosion Board in cooperation with the MDC on 12 September 1947. The following paragraphs give a summary of information contained in the report along with report recommendations and measures taken as a result of the report.

The shore area studied in the report is located on the Atlantic Ocean in the town of Winthrop, in the metropolitan Boston area 3 miles north of the main entrance channel to Boston Harbor and four and one half miles northeast of the city of Boston. The study area is shown on the project map at the end of this section.

Winthrop Beach was and still is a highly developed densely populated, residential area extending a distance of 2 miles along the shore between two headlands, Grovers Cliff on the north and Winthrop Head on the south. Both of these headlands have been badly eroded in the past, supplying material to the adjacent beaches and leaving a mass of boulders, shoals and bars exposed at low tide. At the time of the study both headlands had been protected against erosion to such an extent that very little material from them was available to nourish Winthrop Beach. The beach in its natural state is

exposed to the full fury of North Atlantic storms. At the time of the study the beach was composed of sand, gravel, shingle and cobbles occurring in varying proportions as material was shifted by wave action. A number of protective structures have been built along the Winthrop Beach shoreline. The structures which existed at the time of the study are discussed briefly in the following paragraph.

The most extensive structure is the granite-faced seawall originally constructed by the MDC in 1899 between groin No. 1 on the north and Beacon Street on the south, a distance of about 7,200 feet. The base of Grovers Cliff is protected by riprap and sea walls. Just west of this area a short rubble masonry seawall which was constructed by a private party joins up with the MDC Winthrop Highlands seawall. The first 60 feet of the Winthrop Highlands seawall is of rubble masonry construction. The next 800 feet of the wall is constructed of concrete with a stepped face of granite blocks. Just south of this wall the former Boston, Revere Beach and Lynn Railroad constructed a wooden bulkhead to protect their roadbed. In 1933 this bulkhead was replaced with a steel sheet pile bulkhead the southern end of which joins the MDC Winthrop Shore Drive seawall. As was mentioned earlier, this is a granite-faced seawall extending south for a distance of 7,200 feet. At the southern end the Massachusetts Department of Public Works constructed a concrete seawall around the base of Winthrop Head to protect the headland and stabilize the shoreline. The Massachusetts Department of Public Works also constructed an offshore granite block breakwater consisting of five detached sections approximately 1,000 feet offshore starting from Pearl Avenue on the north to Perkins Street on the south, a distance of approximately 2,250 feet. This breakwater has afforded considerable protection for the section of beach and seawall directly opposite it. Other sections of the seawall along Winthrop Beach have experienced periodic damage during severe storm conditions.

Up to the time of the study the history of shoreline changes in the beach indicated that the entire length of beach had been losing material. This loss resulted in an inadequate supply of sand and erosion of the beach as a whole.

These conditions interested the MDC in having the study conducted to determine the best method of preventing further erosion, stabilizing and improving the beach and protecting the existing Winthrop Shore Drive seawall between groin No. 1 and Beach Street. The report found that north of groin No. 1 and along the shoreline of Grovers Cliff the existing armoring by seawalls and riprap revetments provided adequate protection for shore property. The same was true south of Beacon Street, where the existing Winthrop Head seawall was found to provide adequate protection. For the section of the beach lying

between Pearl Avenue and groin No. 6, the offshore breakwater was found to be an effective method of preventing further erosion, stabilizing and improving the beach and protecting the seawall. It was further determined that along the beach north of the offshore breakwater, that after reconstruction of the seawall by the MDC between groin No. 2 and Trident Avenue the wall will provide adequate protection to the backshore area. However, the reconstructed wall will not, of course, have any effect in retarding erosion of the beach in front of it. As a future maintenance measure, placement of more riprap toe protection than that initially provided would be required to insure continued stability of the reconstructed wall. Therefore, the study addressed itself to accomplishing the following objectives:

- 1) Protection of property between Trident Avenue and Pearl Avenue and between groin No. 6 and Beacon Street.
- 2) Stabilization and improvement of the beach north of Pearl Avenue and south of Irwin Street.

The methods of achieving these objectives were evaluated during the course of the study and include the following:

- 1) Extension of the offshore breakwater to the north and to the south.
- 2) Reconstruction of the existing seawall.
- 3) Artificial nourishment of the beach with sand.

Extension of the breakwater northerly to a point near Grovers Cliff and southerly to a point opposite Winthrop Head would provide protection to the shore area immediately behind it comparable to that being provided to the shore area behind the existing breakwater. However, it was felt that extension of the accreted sand which had occurred opposite the existing breakwater to the adjacent sections of beach opposite the extended sections was not likely to occur except as a result of erosion of the existing accreted area. Furthermore, the cost of extending the breakwater would be prohibitive as compared to the cost of the other methods. In view of these facts the Board and the MDC agreed that the breakwater extension was not a feasible method to reach the desired objectives.

Various plans of improvement were formulated based on the other two methods and were included in the interim report by the Beach Erosion Board dated 6 August 1946. Subsequently, the MDC after study of the interim report, decided to extend the seawall reconstruction, previously initiated in effecting repairs to a section of the wall,

south of Trident Avenue. This decision modified the plans which were developed to meet the objectives and accommodate this work.

The most practicable method of meeting the objectives as determined by the study is shown on the project map at the end of this section and is comprised of the following:

1. North portion of beach:

- a. Extension of seawall reconstruction from Trident Avenue to Wave Way, a distance of 400 feet.
- b. Raising the height of existing seawall 2-3 feet between Wave Way and Pearl Avenue, a distance of 200 feet.
- c. Protection of wall north of Pearl Avenue by additional rock revetment placed along the toe of the wall as required maintenance.
- d. Construction of groins and placement of sandfill between base of Grovers Cliff and Pearl Avenue, a distance of 2,400 feet.

2. South portion of the beach:

Raising height of existing seawall 2-3 feet, construction of groins, and placement of sandfill, between Irwin Street and Beacon Street, a distance of 1,600 feet.

It was determined that items 1 (a), (b) and (c) above together with the wall reconstruction and placement of riprap by the MDC, already underway, would provide positive protection to the area behind the seawall north of the existing offshore breakwater, but would not bring about any improvement in the beach seaward of the wall. Item 1 (d) was included to provide the desired improvement to the beach. Reconstruction of the wall will: (a) Increase the top elevation to at least 24 feet above mean low water; (b) lower the toe of the seawall, provide a steel sheet pile cut-off wall and riprap blanket for protection against undermining; (c) increase the effective cross section to provide adequate strength to resist wave action.

Item 2 above was designed to provide maximum protection to the existing wall in the south portion of the beach and to the area behind it. The top elevation of the proposed sandfill was 20.0 feet above mean low water. It was also proposed to raise the top of the wall by the addition of one course of stone on top,

bringing the average top elevation to 22.0 feet above mean low water between Irwin Street and the south end of the existing wall.

An economic analysis was performed to determine the first cost, annual charges, benefits and benefit-cost ratio associated with the recommended plan.

The first cost of the recommended plan of protection and improvement was estimated to be \$648,000. This estimate included monies for 400 linear feet of seawall reconstruction, 1,100 tons of stone to cap the seawall, 14,000 tons of stone for groin construction, 200,000 cubic yards of sandfill, engineering and contingencies. Based on this estimated first cost the annual charges including interest and amortization of the investment for 40 years were estimated by the Board to average \$44,575. This figure was based on a directed interest rate of 3% for the federal cost and 3½% for non-federal cost.

The estimated annual benefits that would result from construction of the improvement project would be derived from prevention of direct damages, prevention of indirect damages, increased value of land resulting from added protection and additional recreational benefits. It was not possible to place a monetary value on the prevention of indirect damages. A breakdown of the other evaluated benefits follows:

	<u>Estimated Average Annual Benefit</u>		
	<u>Public</u>	<u>Private</u>	<u>Total</u>
Direct damages prevented	\$15,000	\$ 2,400	\$17,400
Increased land values including increased tax revenues	2,300	2,100	4,400
Recreational benefits (increased rentals of adjoining private property)	7,020	15,780	22,800
Total -----	\$24,320	\$20,280	\$44,600

The resulting ratio of the estimated average annual benefits to the estimated annual cost was therefore found to be approximately 1 to 1. In addition, the fact was considered that the project would provide for other intangible benefits which would not be assigned a monetary value.

Based on the findings during the course of the study the report recommended the following:

- 1) The Commonwealth of Massachusetts adopt the plan of protection and improvement described in the report.

- 2) A project be adopted by the United States authorizing federal participation by the contribution of federal funds in an amount equal to one-third of the first cost of the protection and improvement of the shore of Winthrop Beach, Massachusetts which comprises extending of the reconstruction of the existing seawall for a distance of 400 feet, raising the height of the existing seawall 2-3 feet for a length of 1,800 feet, protecting the reconstructed wall and adjacent sections by placement of riprap as required maintenance, constructing eight stone groins with an aggregate length of 3,400 feet and placing 200,000 cubic yards of sandfill.

At the time of the study it was estimated that the total cost of the study would be \$648,000. This estimate was based on monies for 400 linear feet of seawall reconstruction, 1,100 tons of coping stone, 14,000 tons of stone for groin construction, 200,000 cubic yards of sandfill engineering and contingencies. Of this total the federal share was estimated to be \$216,000 and the nonfederal \$432,000.

The project recommended in the report was adopted by the River and Harbor Act of 17 May 1950. Revision of the initial design of the project was approved by the Chief of Engineers on 22 September 1953. This revision provided for reduction of the aggregate length of groins to 2,300 feet, of which all but 760 feet could be deferred, and for placement of sandfill to revised grades and slopes, resulting in an increase in beach fill volume to 245,000 cubic yards. The cost sharing aspects of the project were modified by the River and Harbor Act of 1962 which provided for federal participation in the amount of one half the cost of the uncompleted groin construction.

To date, the project is about 82% complete. To complete the project would require the construction of 3 groins which are now in a deferred status and the placement of riprap toe protection as required for local maintenance.

The work to date which has been completed on the project has been done in stages starting in 1950 and ending in 1959. The total cost of the completed work has amounted to \$529,701 including the federal share of \$176,567. The total cost of the project to date has included monies for 4,157 cubic yards of masonry excavation, removal of 1517 linear feet of fence, 630 linear feet of iron railing, 134 tons of steel sheet piling, 47,960 pounds of reinforcing steel, 1,897 cubic yards of reinforced concrete, 60 linear feet of cast iron pipe, 1,829 linear feet of granite coping, 24,893 tons of stone, 139 linear feet of wooden pile markers, 284,962

cubic yards of sandfill and monies for supervision, administration, engineering and design. For the sandfill 243,167 cubic yards was obtained by hydraulic dredging offshore in the area of the northerly half of the breakwaters. The remaining 41,795 cubic yards of sandfill was truck-hauled to the area from nearby borrow pits.

Almost from the time the sandfill was first placed between the groins a considerable amount of erosion was experienced in the area north and south of the offshore breakwaters. The beach area fronted by the offshore breakwaters remained stable. A number of cobbles and shingles were deposited on the beach north and south of the breakwaters and the beach became almost nonexistent during periods of high tide in these areas. Starting in 1963, it was noted, the groins No. 3 and No. 5 began to experience some damage. The backshore walls remained in fairly good condition but were vulnerable to direct wave attack north and south of the breakwaters.

From about 1963 through 1970 the situation remained fairly stable. There was no sandy beach above the mean high waterline in the areas north and south of the offshore breakwaters. Groins Nos. 4 and 5 were damaged and in need of repair. The seawalls in this area were vulnerable to direct wave attack and were experiencing some periodic damage.

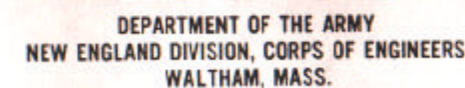
In 1971, the MDC placed about 30,000 cubic yards of sandfill on the beach between Pearl Avenue and Tewksbury Street. The following year it was noted that a lot of this material had been lost. Since that time the area has experienced periodic erosion and accretion. The walls in the area have been adequately maintained and afford good protection to the backshore roadway and structures except during severe storms.

Past experience indicates that it will be very difficult to maintain any type of sandy beach area in front of the seawalls north of the offshore breakwater. The groin structures in this area also do not appear to be effective in maintaining sandfill. The seawall in this area has been effective in minimizing damages to the backshore area and should continue to be maintained, and measures should be taken to guard against undermining as needed.

The beach area directly landward of the offshore breakwaters is afforded a lot of protection by them and has been found to be relatively stable. A build up of shingles and cobbles in this area occurs periodically and detracts from the recreational use of the beach. This area should be cleaned regularly and graded to keep it attractive for bathing. The seawalls in this area have been kept in good condition.

South of the breakwater it has also been very difficult to maintain a sandy beach area and it appears that a large amount of annual sand nourishment would be required to keep a beach. This is similar to the situation existing in the area north of the breakwaters. The seawalls in this area have been adequately maintained and are affording good protection to the backshore facilities.

In general the seawalls in the project area are in good shape and have afforded adequate protection to the backshore area. The recreational aspects of the project have been somewhat limited due to the difficulty of maintaining any type of sandy beach area north or south of the breakwater and the need for more annual maintenance and nourishment of the beach area landward of the offshore breakwaters.



QUINCY SHORE BEACH  
QUINCY, MASSACHUSETTS

A beach erosion control study of the Metropolitan District Commission Beaches in Massachusetts was made by the Corps of Engineers, United States Army, in cooperation with the Commonwealth of Massachusetts under authority of Section 2 of the River and Harbor Act approved July 3, 1930, as amended and supplemented. The formal application for the study dated August 9, 1945 was approved by the Chief of Engineers on October 2, 1945. One of the shore areas which was studied was Quincy Shore Beach, Quincy, Massachusetts. The results of that study are contained in the report entitled "Beach Erosion Control Report on Cooperative Study of Metropolitan District Commission Beaches Massachusetts, Part C, Quincy Shore Beach" dated June 1, 1949.

Quincy Shore Beach is a state owned beach located on the northeast shore of Quincy, Massachusetts adjacent to Quincy Shore Drive and Furnace Brook Parkway. The beach area is shown on the attached project map at the end of this section.

At the time of the study approximately 2½ miles of the beach area had been developed for recreational use. Of this total only about 6000 feet of the shoreline at the southeastern end was experiencing erosion.

The problem was basically one of gradual erosion and recession of the shoreline due to wave, tidal and current action especially under storm conditions. The problem was also found to be aggravated by the construction of protective structures along the adjoining shoreline and the lack of natural fill material within the area. The beach was constructed upon a marsh area of peat consistency which also underlies the man-made road and seawalls.

At the time of the study the development behind the beach was a densely populated urban residential area consisting of a wide paved street with parking, numerous houses, small businesses and highways. Protective structures included seawalls, rip-rap reve tment, a parapet wall and drainage structures for streams running under the beach. Several small piers and other wooden structures extend over the beach at both the Squantum and Wollaston Yacht Clubs.

The study determined the most feasible plan of protection and improvement for the beach would consist of several measures as follows:

- a.) Improving the beach between Hovey Street and Rufe's Hummock Seawall, a distance of 8,500 feet, by placing approximately 126,000 cubic yards of sand and gravel and 221,500 cubic yards of sand thereon, to provide a backshore elevation of 15.0 feet above mean low water;
- b.) Constructing a concrete-encased steel sheet-pile bulkhead, having a top elevation of 18 feet above mean low water, between the parapet wall, near Hollis Avenue and the National Sailor's Home seawall, a distance of 4,750 feet;
- c.) Constructing a concrete sea-wall, having a top elevation of 19.2 feet above mean mean low water, in extension of the parapet wall to high ground at Billings Street, a distance of 325 feet;
- d.) Constructing an impermeable stone groin, 200 feet north of the Squantum Yacht Club, and a similar groin 200 feet south of the Wollaston Yacht Club, each groin being 350 feet long and generally 2 feet above the highest adjacent fill;
- e.) Constructing a paved walk behind the recommended bulkhead for a distance of 4,750 feet;
- f.) Constructing a culvert at Sachem Creek, and extending the existing drains across the beach to discharge seaward of the recommended fill.

An economic analysis was conducted during the course of the study to determine the first cost, annual charges and benefits associated with the plan of improvement to determine if there was enough economic justification for federal participation in the construction of a project.

The total first cost of the project was estimated to be \$849,000 based on 1949 price levels. This estimated first cost included monies for 998 tons of steel sheet pile, 1,800 cubic yards of reinforced concrete, 76,000 pounds of reinforcing steel, 135,500 cubic yards of sand and gravel, 1,250 square yards of asphalt, 350 cubic yards of concrete, 828 tons of core stone, 2,708 tons of cap stone, 360 feet of concrete pipe, 65 feet of cast iron pipe, 221,500 cubic yards of sandfill, and engineering fees and contingencies. Of the total first cost the federal share was estimated to be \$283,000 and the remaining \$566,000 was to be born by the local interests. The annual charges associated with this estimated first cost were calculated to be \$45,750. This annual charge was based on a project life of 40 years, a direct interest and amortization rate of 3 percent for the federal

interest and  $3\frac{1}{2}$  percent for the nonfederal interests and consideration for 3,500 cubic yards of periodic sand nourishment.

If the project were constructed a number of benefits could be derived from it. These include benefits from elimination of direct and indirect damages, recreational benefits due to increased use of the beach area and an increased use of the beach area and an increase in the property value in the area due to the added protection. The direct and indirect damages which would be eliminated include loss of land, buildings and decreased expenses for annual maintenance to existing structures. The study estimated that \$20,850 would be saved by the prevention of direct and indirect damages. In the case of increased property values it was determined that all the properties in the area would increase in value by \$15,330. The recreational benefits that could be realized by the increased beach area provided were found to equal \$56,850. The total benefits attributable to the constructed project were found to be \$93,030.

The ratio of the estimated annual benefits to the estimated annual cost was found to be 2.0 to 1 indicating economic justification for federal participation in the construction of a beach erosion control project at Quincy Shore Beach.

Based on the study findings the Division Engineer recommended in the report that the United States adopt a beach erosion control project for Quincy Shore Beach authorizing federal participation in the estimated amount of \$283,000, equal to one-third of the first cost of construction.

The project was adopted by the River and Harbor Act of 3 September 1954. It is shown on the project map at the end of this section.

The project was constructed in two phases. The first phase involved the placement of beachfill and drain extensions. The total cost of phase one was \$450,709.42. This included monies for 209,800 cubic yards of gravel, 110,811 cubic yards of sandfill, 1,035 cubic yards of wall excavation, 128 cubic yards of concrete, 8,146 pounds of reinforcing steel, 660 linear feet of v.c. pipe, 593 linear feet of timber piles, engineering, design, supervision and administration. The sandfill was dry borrow and truck hauled to the area.

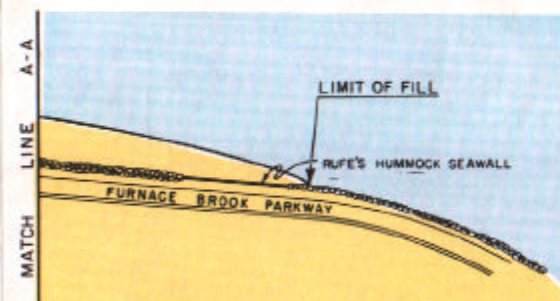
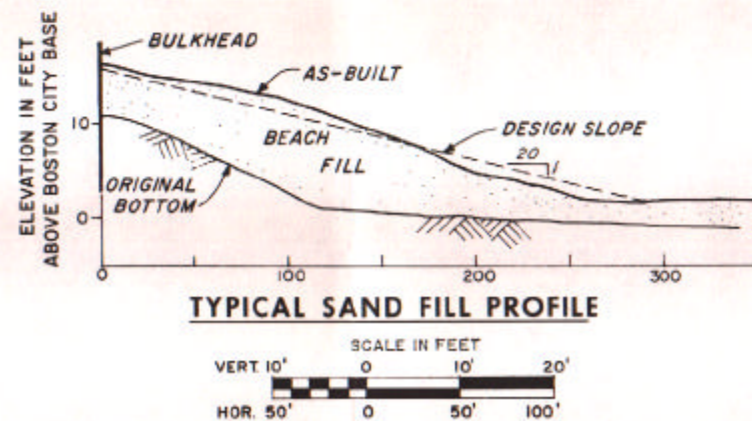
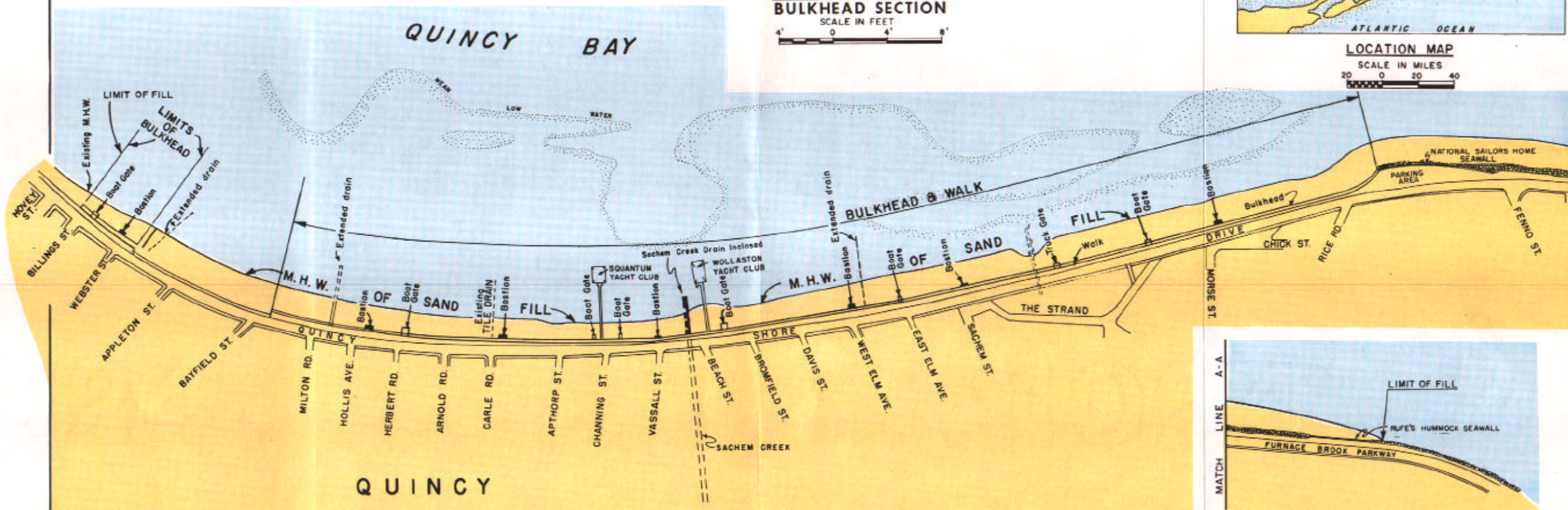
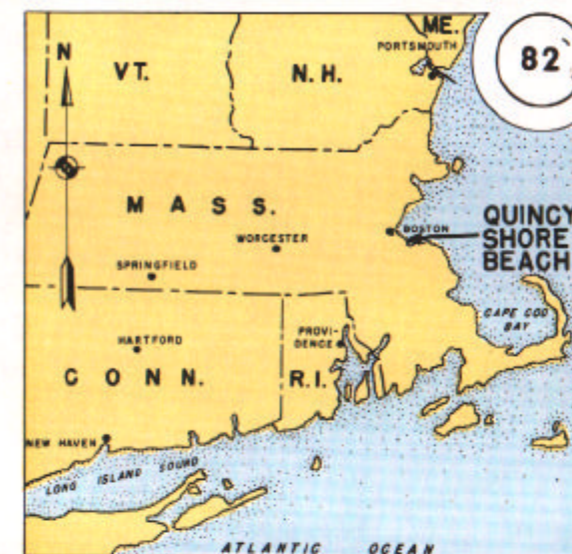
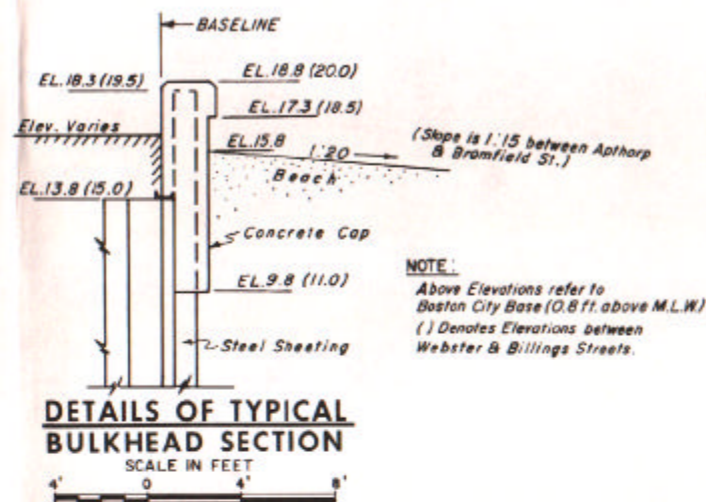
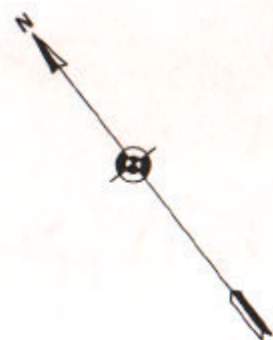
The second phase involved construction of a concrete encased steel sheet pile bulkhead, placement of sandfill and construction of drains. The bulkhead was initially designed to be 4,750 feet in length but had to be extended another 215 feet in length because of imminent failure of the adjacent concrete parapet wall. The total cost of phase two was \$1,301,840.10. This included monies for 13,828 cubic yards of excavation, 21,476 cubic yards of gravel, 242,001 tons of sandfill, 330,586 square feet of protective coating, 5,347,410 pounds of steel sheet piling, 329,400 pounds of structural

steel, 3,212 cubic yards of concrete, 208,023 pounds of reinforcing steel, and 412 linear feet of iron pipe railing. The sandfill was dry borrow and truck hauled to the project site from a nearby borrow pit.

Project construction was completed in August 1959, by the Commonwealth of Massachusetts. The total cost of the project was \$1,864,320, the federal share of the cost was \$621,440.

From the time of project completion in 1959, through 1964 the beach remained fairly stable, and the backshore walls remained in good condition. From 1964 thru 1968 the beach area was noted to be experiencing erosion throughout its length especially in the area south of the Wollaston Yacht Club. The walls did not experience any deterioration. In 1969, the MDC placed 15,000 cubic yards of sandfill on the beach north of the Wollaston Yacht Club, and in 1970, they placed 37,000 cubic yards of sandfill of the beach south of the Wollaston Yacht. Since that time the beach has remained fairly stable. The backshore walls have remained in a good state of repair. The beach is intensely used during the summer bathing season.

Since the project was completed, it has been very successful in serving its intended purpose. It has provided good protection to the backshore roadway and development, and it has added greatly to the healthful recreation of the populace in the area.



## QUINCY SHORE BEACH QUINCY, MASS.

30 SEPTEMBER 1976

IN 1 SHEET  
SCALE IN FEET  
300 0 300 600

DEPARTMENT OF THE ARMY  
NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
WALTHAM, MASS.

WESSAGUSSETT BEACH  
WEYMOUTH, MASSACHUSETTS

A beach erosion control study for Wessagusset Beach in the town of Weymouth, Massachusetts, was conducted by the New England Division of the U.S. Army Corps of Engineers in Cooperation with the town of Weymouth under authority of section 2 of the River and Harbor Act approved July 3, 1930, as amended and supplemented. The formal application for the study dated 3 January 1958, was approved by the Chief of Engineers on 3 March 1958. The results of that study are contained in the report entitled "Beach Erosion Control Report on Cooperative Study of Wessagussett Beach, Weymouth, Massachusetts" dated 17 April 1959.

Wessagussett Beach is a town owned beach located on the north shore of Weymouth between the Wessagussett Yacht Club and the Fort Point Seawall. The beach is shown on the project map at the end of this section.

At the time of the study, approximately 3,100 feet of beach was developed for recreational use. Of this total about 2,600 feet of shoreline was experiencing serious erosion.

The problem was basically one of gradual erosion and recession of the shoreline due to wind, wave, tidal and current action in the area. The problem was aggravated by the advanced development of the shore area and the presence of new protective structures which eliminated the former sources of supply of littoral material.

At the time of the study, the development behind the beach consisted of a paved access road, a paved parking area, a bathhouse, a yacht club, several commercial establishments and individual residences. Protective structures included retaining walls, groins, cribbing and riprap.

The study evaluated a number of measures that could be taken to alleviate the problem and determined that formulation of the most feasible plan of protection and improvement for the beach could be easier by considering the beach area in two sections. The plans of protection developed for the two sections are described as follows:

a. Wessagussett Road Section-Sandfill, Groin Construction and Drains

Enlarging about 1,000 feet of beach to a width ranging from 35 to 125 feet by direct placement of suitable sandfill, construction of a stone groin 375 feet long containing a drain pipe with a tide gate, and construction of drainage facilities.

b. Regatta Road and River Street Section - Sandfill, Groin Construction, Stone Mound Construction

Widening about 1,600 feet of beach to a general width of 125 feet by direct placement of suitable sandfill along River Street and Regatta Road, construction of a stone groin 350 feet long and construction of two stone mounds, each 500 feet long, along the westerly end of the Regatta Road section and at the easterly end along the River Street section.

An economic analysis was conducted during the course of the study to determine the first cost, annual charges and benefits associated with the plan of improvement to determine if there was enough economic justification for federal participation in the construction of a project. The total first cost of the project was estimated to be \$404,000 based on 1959 price levels. This estimated first cost included monies for 175,000 cubic yards of sandfill, 12,500 tons of stone for groins and stone mound construction, contingencies, engineering, design and supervision and administration.

The annual charges associated with this first cost were calculated to be \$19,300 of which \$6,700 was assigned to the Wessagussett Road section and the remaining \$12,600 to the Regatta Road and River Street section. These values were based on an interest rate of 2.5 percent for the federal interest and 3.0 percent for the nonfederal interest over a 50 year economic project life. The annual charges contain monies for 2,000 cubic yards of annual sand nourishment and 130 tons of stone for groin and stone mound maintenance.

Two types of benefits would be realized from project construction: elimination of direct damages and increased recreational use of the area. An estimate of the amount of direct damages that would be prevented by project construction was based on records of expenditures for repairs to public roads and facilities and on estimates of damages to and loss of privately owned structures and land. The recreational benefits would be derived from increased use of the improved bathing area.

In the Regatta Road section it was estimated that \$200 worth of damages to public land and \$800 worth of damages to private property would be prevented annually by construction of the project. For the Wessagussett Road section it was determined that damage to the bathhouse would be reduced and damage to Wessagussett Road would be eliminated with the proposed improvement at an estimated saving to the town of Weymouth of about \$4,000. It was further estimated that \$200 worth of annual damages to private property would be eliminated if the project were constructed. The recreational benefits which would be provided were estimated to equal \$15,600 annually in the Wessagussett Road section and \$21,300 annually for the Regatta Road - River Street section. The total annual benefit for the project was found to be \$39,900.

The ratio of the estimated annual benefits to the estimated annual cost was computed to be 2.3 for the Wessagussett Road section and 1.9 for the Regatta Road and River Street section indicating economic justification for federal participation in both portions of the project.

Based on the study findings, the Division Engineer recommended that the United States adopt a beach erosion control project for Wessagussett Beach authorizing federal participation in an amount of \$132,000 which is equal to one-third of the first cost of construction.

The project was adopted by the River and Harbor Act of 14 July 1960, and modified by the River and Harbor Act of 1962. These acts provided for federal participation by the contribution of federal funds in an amount equal to one-third of the first cost of construction of the Wessagussett Road section of the project and one-half the cost of the Regatta Road and River Street section. The project was completed at a total cost of \$381,152 prior to June 1971. The federal share of which was determined to be \$180,944.

Construction of the project was carried out in two stages. The first stage dealt with the Wessagussett Road section and was completed at a total cost of \$57,791.63. This included monies for 4,525 tons of stone, 31,498 cubic yards of sandfill, 368 linear feet of 42" pipe and fees for engineering, design, supervision and administration. The work was completed in 1963.

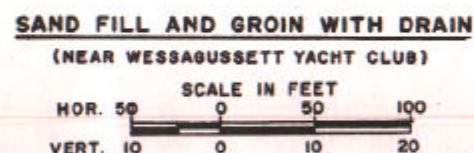
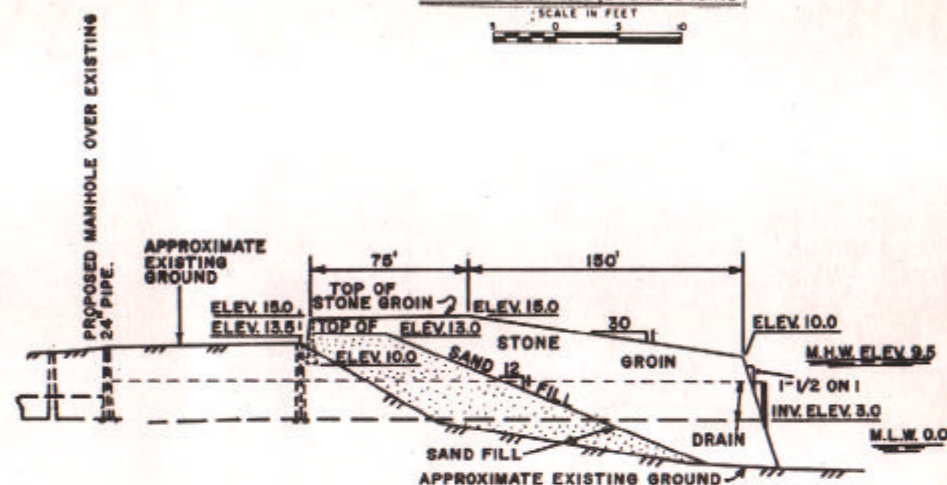
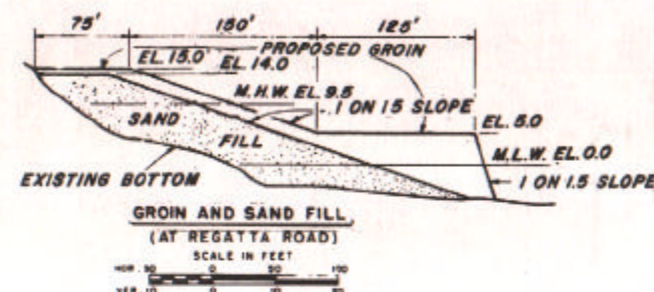
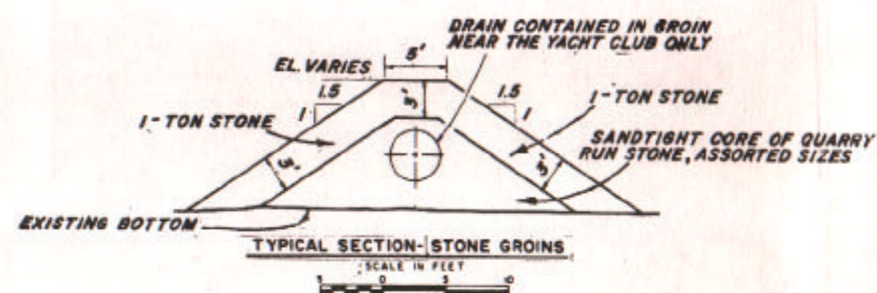
The second stage of construction of the project, for the Regatta Road and River Street section, was completed in April 1969, at a total cost of \$323,359.05. This included monies for 5,307 tons of stone and stone chips, 1,540 tons of crushed stone, 5,733 tons of cover stone, 2,237 cubic yards of ordinary borrow, 500 linear feet of concrete seawall, 151,981 cubic yards of sandfill and fees for engineering, design, supervision and administration. The sandfill for the project was truck hauled from a nearby land based borrow area.

Since project construction, the town of Weymouth has been very diligent in providing all the required maintenance to ensure its continued effectiveness. Just prior to the beginning of each beach season the town has been placing about 2,400 cubic yards of sand on the beach to replace what was lost to erosion over the winter months. The beach is also graded and thoroughly cleaned at the beginning of each beach season. In addition, the town has provided periodic maintenance, as required, for the groins and stone mounds, allowing them to effectively accomplish their intended purpose.

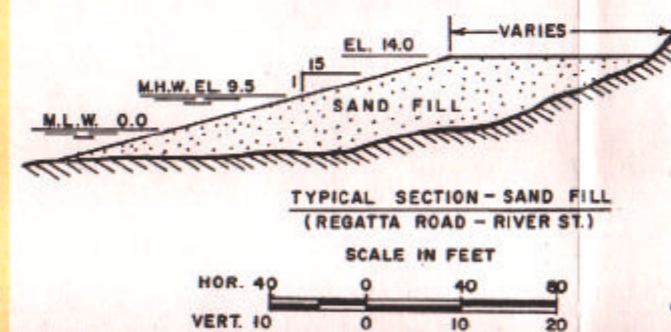
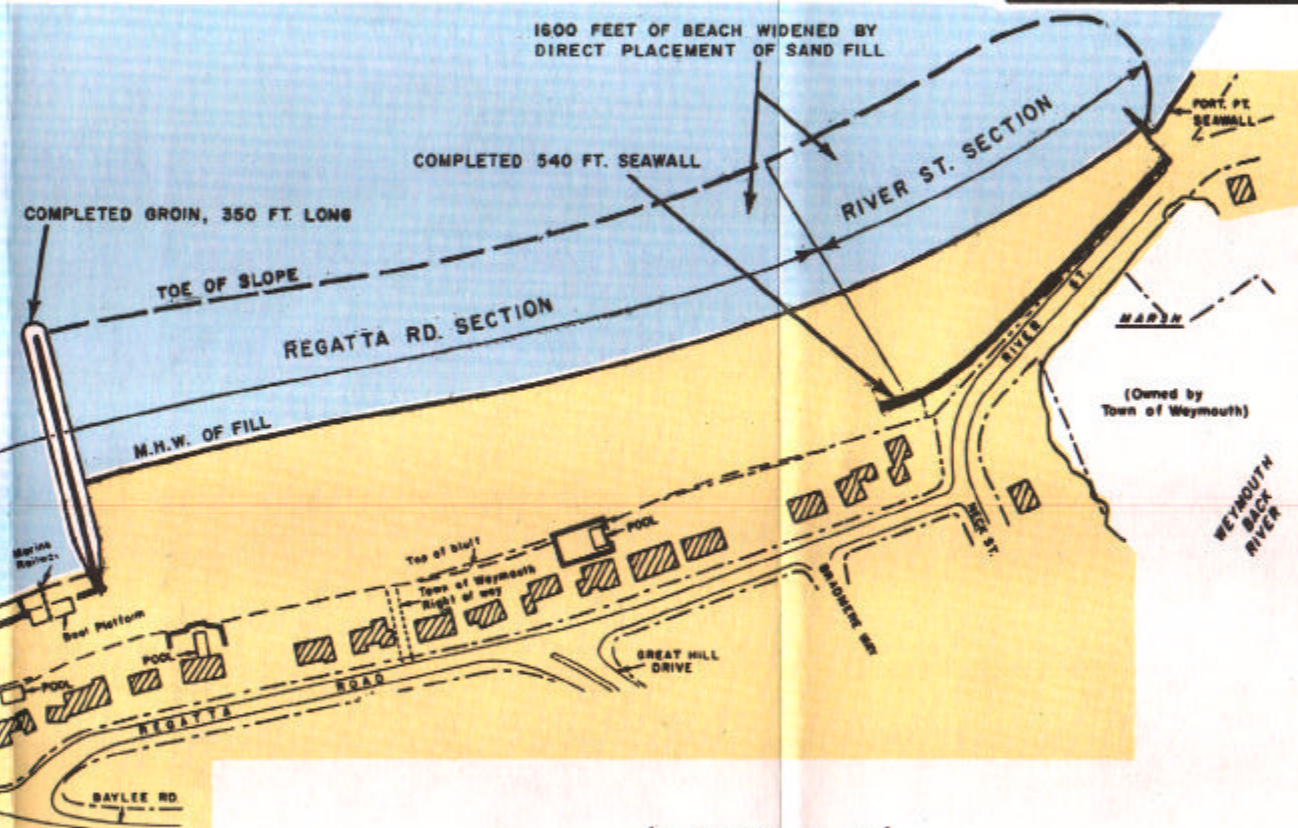
During the summer months the beach area is intensively used for swimming and sunbathing by the local residents and visitors to the area. The area is well maintained by the community and, as a result, has become a very attractive recreational area for a number of people. In addition, the beach and stone mounds have provided adequate protection for the backshore roadway and facilities during storm conditions.

The project has been very successful to date in serving its intended purpose. It is felt that it will continue to do so as long as the community continues to provide the required maintenance to ensure the integrity of the project.

84.1



COMPLETED 500 FT. STONE MOUND



# WESSAGUSSETT BEACH, WEYMOUTH, MASS.

30 SEPTEMBER 1976

IN 1 SHEET

SCALE IN FEET

DEPARTMENT OF THE ARMY  
NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
WALTHAM, MASS.

NORTH SCITUATE BEACH  
NORTH SCITUATE, MASSACHUSETTS

A beach erosion control study including North Scituate Beach was made by the New England Division of the Corps of Engineers, United States Army, in cooperation with the Commonwealth of Massachusetts (acting through the Department of Public Works, Division of Waterways), under authority of Section 2 of the River and Harbor Act approved July 3, 1930, as amended and supplemented. The Commonwealth made a formal application for the cooperative study on 13 June 1950 and it was approved by the Chief of Engineers on 20 July 1950. The initial study area included only the shore between Pemberton Point and Gurnet Point, Massachusetts. At the request of the Commonwealth by letter dated 31 October 1956 and approved by the Chief of Engineers on 3 December 1956 the study area was extended to include the shore between Plymouth (Long) Beach and the northerly entrance to the Cape Cod Canal. North Scituate Beach, located in Scituate, Massachusetts was one of the beach areas included in the study. The results of the study are contained in the report prepared by the New England Division of the Corps of Engineers entitled "Beach Erosion Control Report on Cooperative Study, Pemberton Point to Cape Cod Canal, Massachusetts", dated 31 July 1957.

North Scituate Beach is located along the northern portion of the shoreline of the town of Scituate, about 20 miles south of the city of Boston and just a short distance south of the entrance to Cohasset Harbor. At the time of the study the beach was backed by concrete and stone masonry seawalls, a roadway and several residential structures. The orientation of the shoreline makes it susceptible to storm driven wave attack from the northeast thru the southeast quadrants. The most frequently occurring and damaging storms approach from the northeast quadrant. The location of the study area is shown on the project map at the end of this section.

The problem occurring is generally one of erosion and recession of the shoreline caused by wind, wave, current and tidal action and resulting in lowering the elevation of the beach berm and decreasing the width of the beach above the mean high waterline. This allows storm driven waves to run up and overtop the beach and the backshore seawalls causing damage to the walls and flooding and damage to the backshore roadway and residences. This situation was aggravated by the construction of protective structures along the adjoining shorelines which have greatly reduced the supply of littoral material to the shore which formerly helped to maintain the natural equilibrium. At the time of the study the north end of North Scituate Beach had become quite narrow and very little dry beach area was remaining above the mean high waterline. At the south end of North Scituate Beach the shingle barrier which was affording protection to the low backshore from ocean flooding during extreme tides was eroding along the face and at points along the crest.

During the course of the study it was determined that the best method of affording protection to the backshore seawalls, roadway and residences would be through beach restoration by the artificial placement of sand-fill to provide a beach berm of approximately 125 feet in width for a distance of about 2,500 feet in the northerly portion of the North Scituate pocket beach. It was felt that this beach area had a limited along-shore movement of material and limited southward movement of material, therefore, the use of groins was not necessary.

In order to make an evaluation to determine if federal participation and cost sharing in an improvement project at North Scituate Beach would be feasible, it was necessary to make an economic analysis. This is normally done by making a comparison of the annual costs associated with an improvement project and the annual benefits which would be derived if the project was constructed. However, at the time of the study North Scituate Beach was a membership beach owned by a private association. The protection plan which was developed provided only minor public benefits from protection of the public street and seawall; the remainder of the benefits would be private in nature. The public benefits that could be expected from the plan for North Scituate Beach were felt to be insufficient to warrant further consideration for eligibility of the plan for federal aid under Public Law 826, 44th Congress.

Estimates of the first cost and annual charges were developed for the plan of protection for the North Scituate Beach area for use by local interests if they so desired. The first costs were based on 1957 price levels and an interest and amortization rate of  $2\frac{1}{2}$  percent for a fifty year project life.

The estimated first cost was found to be \$160,000. This was based on funds for 100,000 cubic yards of sandfill, contingencies, engineering, design, supervision and administration. The annual charges associated with this first cost were determined to be \$10,100. This included an allowance for 3,000 cubic yards of annual beach nourishment.

In the report the Division Engineer concluded that the plan for North Scituate Beach was practical and would protect and improve the shore area. He further recommended that protective measures which may be undertaken by local interests, based on their own determination of economic justification, be accomplished generally in accordance with the methods proposed and considered in the report. The plan of protection for North Scituate Beach is shown on the project map at the end of this section.

Local interests were informed of the report findings and recommendations of the Division Engineer and invited to present additional information for consideration by the Beach Erosion Board. As a result, the cooperating agency requested reconsideration of the eligibility

of North Scituate Beach for federal aid in view of its possible acquisition and operation by the town of Scituate as a public beach. Consequently the Division Engineer made an analysis to determine what benefits could be derived if a beach erosion control improvement project were constructed at North Scituate Beach. The benefits that were developed would be derived from prevention of direct damages to the backshore seawalls, roadway and residences and to encourage the healthful recreation of the populace. The estimated annual benefits were evaluated to be \$18,550. The resulting benefit-to-cost ratio was found to be 1.8. This indicated there was economic justification for federal participation in a project at North Scituate Beach.

Accordingly, the Division Engineer recommended adoption of a project by the United States authorizing federal participation, subject to certain conditions, by the contribution of federal funds in an amount equal to one-third the first cost of construction. The Beach Erosion Board concurred with the findings of the Division Engineer that the project for North Scituate Beach was justified by prospective benefits and that the public interest involved in the project warrants federal aid in initial construction under established policy, provided a public agency acquired ownership or suitable rights to assure realization of the public benefits evaluated by the Division Engineer. For North Scituate Beach, the most suitable and economical remedial measure was considered to be provisions for periodic nourishment, therefore, such nourishment was eligible for federal aid.

The project was adopted by the River and Harbor Act of 14 July 1960 and the cost sharing aspects of the project were modified by the River and Harbor Act of 1962. Assurances were obtained from the local interests and private property owners in the project area that the beach would be open to public use for the life of the project after its construction.

Construction of the authorized project was completed in February 1967 at a total cost of \$213,104. The sandfill for the project was obtained from a nearby land based borrow pit and truck hauled to the site. The total cost of the project included monies for engineering, supervision and administration for both the federal and non-federal share as well as for 159,939 cubic yards of sandfill. The federal share of \$106,552 for the project was reimbursed to the local interests in September 1968.

Two years after completion of the initial project it was found that 90,000 cubic yards of beachfill had been lost. This was 15 times greater than the estimated annual losses that had been expected to occur after the project was constructed. This excessively high annual loss prompted a revaluation of the project to be made. The results of this revaluation are contained in a report prepared by the Department of the Army, New England Division, Corps of Engineers entitled "Beach Evaluation Study, North Scituate Beach, North Scituate, Massachusetts" dated October 1970.

The purpose of the study was to evaluate the stability and effectiveness of the project as constructed and the accompanying nourishment program to determine if the design and nourishment should be modified. The revaluation was made in line with the latest design principles which included a study of wave induced processes correlated with storm tide levels, field observations and comparative beach surveys.

The major problem involved the rapid loss of beachfill during storms having higher than normal tide levels. These storms occur quite frequently and the waves accompanying them were found to be running up and overtopping the beach causing erosion to the backshore and inflicting damage to the backshore seawalls. These massive seawalls backing the beach were found to be aggravating the problem by reflecting the waves back on the beach causing scouring at the toe of the walls.

Fourteen beach profiles surveyed in the years 1965-1967 and 1969 were used to compute the volumetric losses of sandfill. These surveys showed the physical dimensions of the beach immediately before and after construction in 1965 and 1967 respectively, with the 1969 profile showing the erosion which had occurred since the project was constructed. They revealed that the mean high waterline had moved landward between 70 and 90 feet in the two years since the project was completed along most of the northerly three-quarters of the project. Proportionately this represents nearly 100 percent loss of the artificially placed sandfill for the north half of the project with from 40 to 70 percent losses for the southern half.

A revaluation of the benefits and costs associated with the authorized project revealed that the estimated annual periodic nourishment requirement for beachfill was very low. The use of a higher more realistic estimate based on losses experienced since construction of the project would cause it to be economically unjustified, therefore, project modification was considered. Additional plans which were evaluated included raising and widening the beach, with and without groins, providing a beach with a 50 foot wide berm at elevation 17.0 feet above mean low water with a seaward slope of 1 vertical on 15 horizontal to the mean high waterline, thence 1 vertical on 20 horizontal. Also, consideration was given to providing stone revetment along about 800 feet of seriously damaged wall, as a northerly continuation of existing revetment rather than the beach fill.

The first cost associated with these additional considered plans was found to range from \$100,000 for the partial revetment plan fronting the damaged sector of seawall to \$840,000 for the cost

of providing a beach estimated to be required for stability. These costs were based on 1970 price levels. The benefit to cost ratio of all the plans, under the 1970 conditions of development for the area were found to lack economic justification.

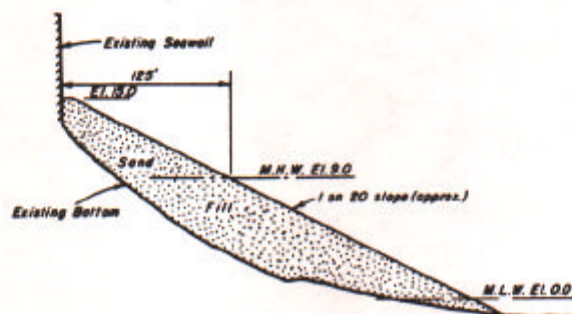
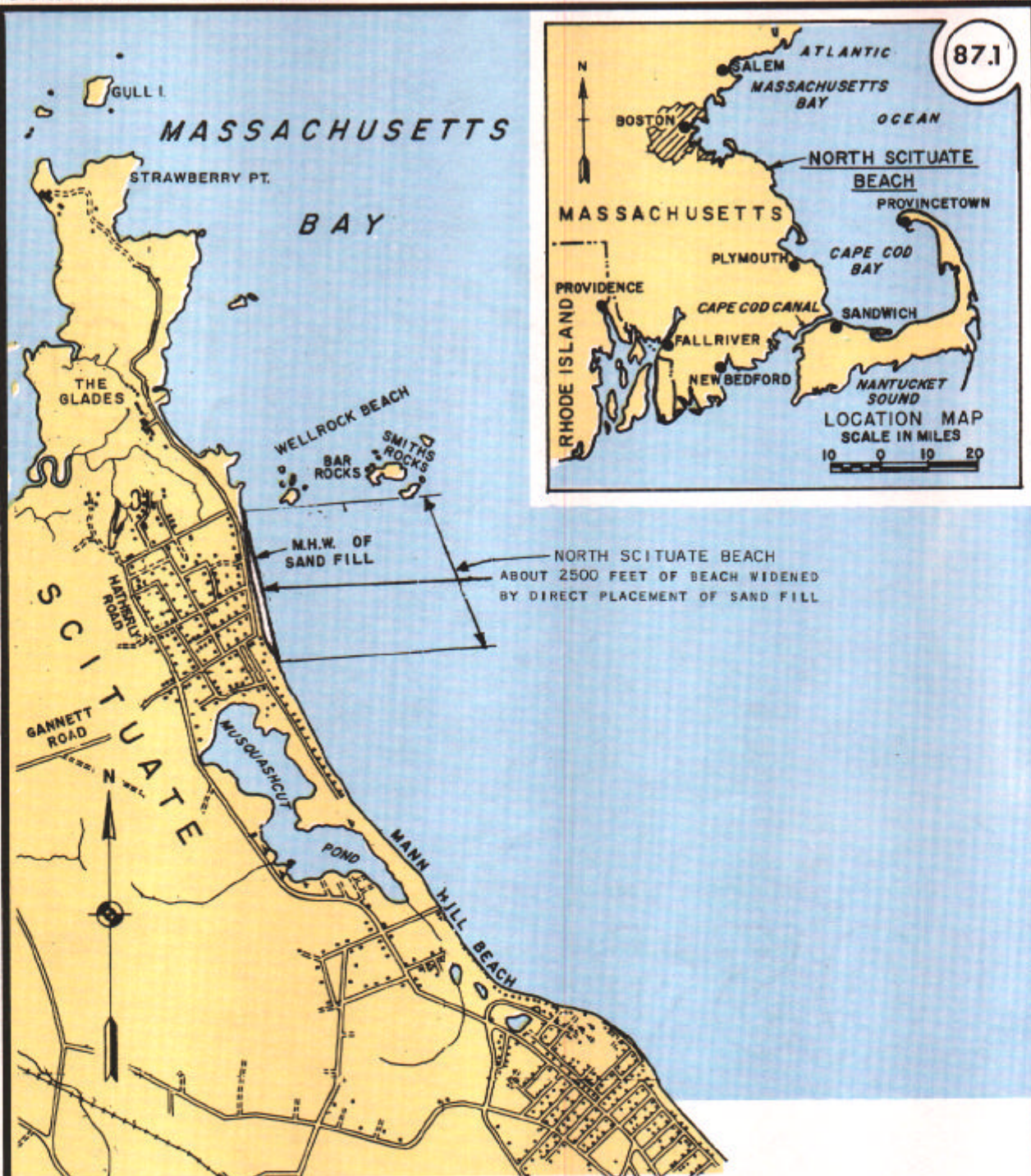
The report concluded that the beach, as constructed, afforded very limited protection against wave action with the backshore elevation being at or close to the elevation of frequent wave runup during severe storms. The beach fronting these massive vertical face concrete seawalls had been subjected to substantial wave reflection resulting in a large loss of beach material. It was further concluded that renourishment to the authorized project dimensions was impractical and not economically feasible since periodic nourishment requirements would continue to be excessive. It was felt that the addition of a strategically located groin structure to the existing project would not substantially reduce losses which were found to be predominantly offshore through wave reflection.

In view of the complexity of the problems associated with the wave induced processes at this beach, the report recommended that the Coastal Engineering Research Center include this beach in their coastal evaluation study program, for analysis and recommendations of future courses of action for the project. To date the report recommendation has not been carried out.

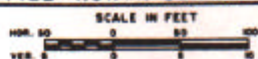
On 18 March 1972, a severe northeast coastal storm caused an extensive amount of damage to the backshore seawalls in the project area. An inspection of the area just after the storm revealed that the upper slopes and a low rubble wall founded on the upper embankment level bordering the street, had been badly torn up along the northerly sector of the project. The seawalls along this sector (about 800 feet adjacent to and north of a revetted sector) were badly damaged and in some segments were approaching collapse. If repairs were not made it appeared the lives of the general public who use the beach would be endangered.

At the request of the Federal Disaster Assistance Administration the Corps contracted and monitored the work involving the restoration of the concrete seawall, retaining wall, sidewalk and slope behind the wall to the edge of the road at North Scituate Beach. The work consisted of removing failed sections of the concrete wall, repairing the structural cracks with injected epoxy resin and patching wall sections. About 785 feet of wall was restored by repairing structural cracks, facing with structural concrete and toed riprap. About 50 feet of wall was removed and replaced in kind. About 785 feet of sidewalk and retaining wall was removed and replaced and the slope reshaped and restored. This work was done at a total cost of \$240,687.

87.1



SAND FILL - NORTH SCITUATE BEACH

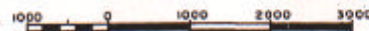


## NORTH SCITUATE BEACH MASS.

30 SEPTEMBER 1976

IN 1 SHEET

SCALE IN FEET



DEPARTMENT OF THE ARMY  
NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
WALTHAM, MASS.

PLYMOUTH TOWN BEACH  
PLYMOUTH, MASSACHUSETTS

A beach erosion control study of the South Shore of Massachusetts from Pemberton Point to Cape Cod Canal, Massachusetts was made by the Corps of Engineers, United States Army, in cooperation with the Commonwealth of Massachusetts under authority of Section 2 of the River and Harbor Act approved July 13, 1950. The formal application for the study was approved by the Chief of Engineers on July 20, 1950. One of the shore areas included in the study was Plymouth Town Beach, Plymouth. The results of that study are contained in the report entitled "Beach Erosion Control Report on Cooperative Study of Pemberton Point to Cape Cod Canal, Massachusetts", dated 31 July 1957.

Plymouth Town Beach is a town owned beach located on the eastern shore of Plymouth, Massachusetts, just south of Plymouth Harbor on Cape Cod Bay. The beach is shown on the attached project map at the end of this section.

At the time of the study, about 1,300 feet of beach area had been developed for recreational use. The problem was basically one of gradual erosion and recession of the shoreline, which had been ongoing for many years due to wind, wave, tidal and current action in the area. The problem was also aggravated by the construction of protective structures along Rocky Point which reduced the amount of littoral material that previously had been a source of nourishment for Plymouth Town Beach.

At the time of the study the development behind the beach consisted of a bathhouse, parking facilities for 300 cars, and an access road. Also, a concrete seawall ran the entire length of the beach separating the parking area from the beach, and a groin structure was located at the southern end of the beach.

The study determined the most feasible plan of protection and improvement for the area would be by beach restoration consisting of construction of a protective beach 1,300 feet in length and 125 feet wide at mean high water in front of the seawall by direct placement of suitable sandfill. It was further determined that the construction of two stone groins 300 feet long would be required to stabilize the proposed beach. One would be located at the north end of the beach and the other midway between this groin and the existing groin at the south end of the beach.

An economic analysis was conducted during the course of the study to determine the first cost, annual charges and benefits associated with the plan of improvement to see if there was enough economic justification for federal participation in the construction of a project. The total first cost of the project was estimated to be \$95,000 based on 1957 price levels. This estimated first cost included monies for 55,000 cubic yards of sandfill, 2,600 tons of stone for groin construction, contingencies, engineering, design, supervision and administration. The annual charges were established to be \$8,100 based on an interest rate of  $2\frac{1}{2}$  percent for the federal and nonfederal interests and a project life of 50 years. Monies were also included for 3,000 cubic yards of annual sand nourishment and 30 tons of stone for annual groin maintenance.

The two types of benefits that would be realized if the project were constructed would be the elimination of direct damages and increased recreational use of the beach area. The direct damages to be eliminated would include those which have been periodically occurring to the various protective works at Plymouth Town Beach. It was estimated that the prevention of direct damages would average about \$7,840 per year. The recreational benefits would be derived from increased use of the improved bathing area and were estimated to amount to \$3,705 annually. Thus the total estimated annual benefits were calculated to be \$11,545.

The ratio of the estimated annual benefits to the estimated annual cost was found to be 1.3 indicating economic justification for federal participation in the construction of a beach erosion control project at Plymouth Town Beach.

Based on the study findings the Division Engineer recommended in the report that the United States adopt a beach erosion control project authorizing federal participation in an amount equal to one-third of the first cost of construction which was estimated to be \$32,000. The project was adopted by the River and Harbor Act of 14 July 1960 and modified by the River and Harbor Act of 1962. The authorized project provides for federal participation in the amount of one-half the first cost of construction for widening approximately 1,300 feet of beach to 125 feet by direct placement of suitable sandfill and one-third of the first cost of construction of two groins, each about 300 feet long and construction of a concrete seawall and apron approximately 165 feet long. A picture of what the project entails is shown on the project map at the end of this section.

Construction of the concrete seawall and apron was completed by the Commonwealth of Massachusetts in June 1961, for a total cost of \$16,471. This first cost included monies for 364 cubic yards of concrete excavation, 399 cubic yards of cement and concrete, 38 tons of stone, 94 cubic yards of gravel borrow and fees for engineering,

design, supervision and administration. The federal share of the cost of this work amounted to \$5,490 and reimbursement was made to the Commonwealth in 1964. In November 1968, the Commonwealth completed construction of the two stone groins. The actual cost of construction of these structures is not known, and reimbursement for the federal share of the cost has not been made to the Commonwealth to date.

In order to complete the authorized project, 55,000 cubic yards of sandfill has to be placed between the groin structures.

Since their construction, the concrete seawall and stone apron fronting it have held up very well against tidal surge and wave attack. They have provided adequate protection to the backshore facilities. Some stones have been displaced in the stone apron, but the situation is not serious enough to pose a threat to the integrity of the structure.

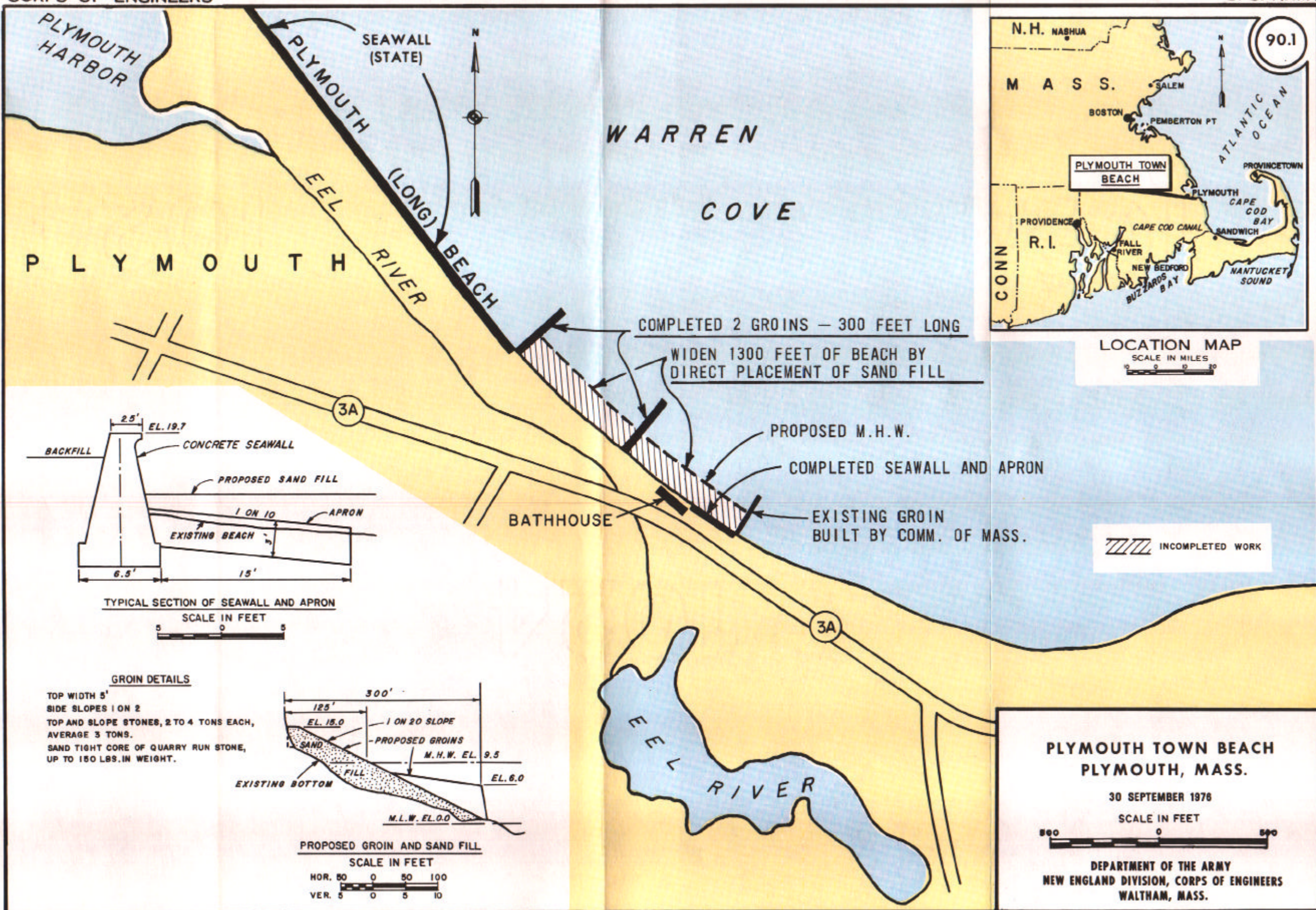
For the first three to four years after their construction, the groins did not suffer any appreciable damage. Since that time, they have been experiencing some periodic damage and are now in need of repair.

At the present time, the beach is very narrow or non existent in front of the seawall in the project area during periods of high tide. This limits the amount of time the beach area can be used for bathing during the day and reduces the attractiveness of the area for potential users. In addition, this situation makes the seawalls vulnerable to direct wave attack during storm conditions.

In order to realize the estimated recreational benefits that would occur if the project were constructed and to ensure the continued integrity of the seawall, it will be necessary to place the needed sandfill in front of the wall and between the groins to complete the project. This sandfill will also provide some protection to the groin structure and make better use of them than has been done to date. It appears that there is not a sufficient amount of sand material moving around in the area that can be trapped by the groins to help build a beach in front of the seawall.

To date, the project has been effective in providing protection to the backshore facilities and structures. However, if the wall is continually subjected to direct wave attack during storms there is no way of telling how soon it will start to break down. The project has not been effective in providing for the recreational needs of the populace due to the lack of dry beach area during high tide.

To date, it is felt that the project is not as effective as it could be in serving its intended purpose. In order to made the project more effective from a recreational standpoint and to ensure the continued integrity of the wall, it will be necessary to completed the project by placing sandfill on the beach between the groins for a distance of 1,300 feet.



OAK BLUFFS TOWN BEACH  
MARTHA'S VINEYARD MASSACHUSETTS

A small beach erosion control study for Oak Bluffs Town Beach was made by the New England Division of the U.S. Army Corps of Engineers, in extension of the cooperative beach erosion control study of the east shore of Martha's Vineyard undertaken in cooperation with the Commonwealth of Massachusetts. The results of the study are contained in the detailed project report entitled "Oak Bluffs Town Beach, Martha's Vineyard, Massachusetts" dated 12 August 1965.

Oak Bluffs Town Beach is owned by and located in the town of Oak Bluffs, in Dukes County along the northeast shore of the island of Martha's Vineyard, Massachusetts. The beach is about midway between Oak Bluffs Harbor entrance to the north and Harts Harbor entrance to the south. The area is shown on the project map at the back of this section.

At the time of the study, residential property, tourist homes, and inns formed the principal development directly behind the beach and landward of the shorefront road. Immediately adjoining the property and behind the northern portion of the beach is an attractive public park. During the summer season the beach is used to its maximum capacity by local residents and tourists, who visit the Vineyard in great numbers. Among the principal assets of the beach are a bathing pavilion and nearby parking facilities.

The location and exposure of the beach area makes it susceptible to wave attack during hurricanes and other severe coastal storms. This has resulted in the gradual landward recession of the shoreline, the lowering of the beach berm, and the loss of beach material. The seriousness of the problem was evidenced at the time of the study by the fact that what had been formerly wide recreational and protective beach had been cut back to a width of only about 10 to 15 feet at mean high tide. This resulted in exposing the backshore seawall and bathing pavilion to attack from wind driven waves. If this situation is allowed to continue, damage to the seawall would result, this in turn would allow increased overtopping of the wall by waves thereby seriously affecting the shorefront road and the residential development directly behind it.

Due to the recreational nature of the area, the increasing demand for additional salt water bathing areas and the availability of suitable sandfill within a short distance of the beach, the study determined that the most practical method of correcting the erosion problem was beach restoration.

The plan of protection and improvement which was developed in the report (shown on the project map at the end of this section) consists of beach raising and widening along 1,200 feet of shoreline in the vicinity of Oak Bluffs Town Beach pavilion and bathhouse. The maximum beach width of about 200 feet would be provided in front of the area with the most intensive development and then tapered as it extends northward and blends in with the existing shoreline. The beach berm would be constructed to an elevation of 7.7 feet above mean low water. Construction of an impermeable stone groin at the southern extremity of the beach would also be a required part of the project to help stabilize the sandfill and reduce sand losses when the waves approach the beach at an oblique angle. The groin would be constructed with a top elevation of 8.7 feet above mean low water at its landward end and to an elevation of 1.0 above mean low water at its seaward end. Even with this groin, a considerable loss of beach material can be expected to occur during severe storm conditions and, therefore, an annual allowance for nourishment of the beach was included in the design and annual cost of the project.

An economic analysis was performed during the course of the study to determine the first cost, annual charges, benefits, and benefit-cost ratio associated with the recommended plan.

Based on prevailing 1965 price levels, the estimated first cost of the recommended plan of protection and improvement was determined to be \$270,000. This first cost included monies for 84,000 cubic yards of sandfill, 8,400 tons of rock for groin construction, contingencies and fees for engineering, design, supervision and administration. The associated annual charges was computed to be \$39,000. The annual charges were based on a fifty year project life, a direct interest rate of 3 1/8% for both the federal and nonfederal interest, and provisions for 15,000 cubic yards of sandfill for annual beach nourishment, and 420 tons of stone for groin maintenance.

The estimated annual benefits that could be attributed to the construction of the improvement project would be derived from prevention of damages to the existing structures and development backing the beach and the increased recreational use of the beach. Other benefits such as prevention of indirect damages and increased property values as a result of the added protection would also result if the project were built, however, it is not possible to put a monetary value on these benefits. The total estimated annual benefits which may be expected to occur if the recommended plan were constructed were determined to be \$53,400. Of this total, \$52,200 of these benefits would result from the increased recreational use of the area.

The resulting ratio of the estimated annual benefits to the estimated annual costs was found to be 1.4 indicating economic justification for federal participation in the construction of a beach erosion control project at the beach.

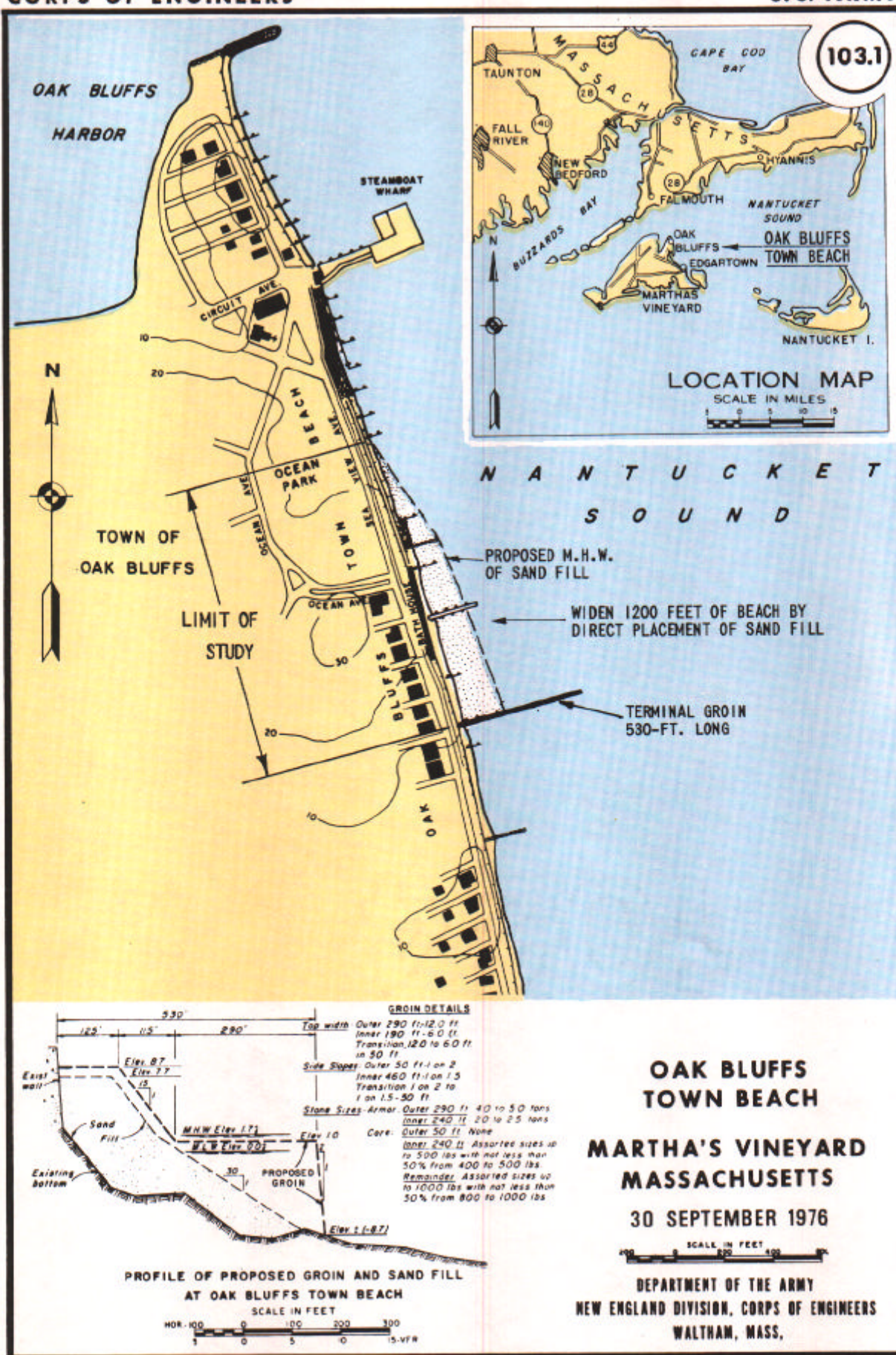
Based on the findings of the study the Division Engineer recommended in the report that a beach erosion control project be authorized for Oak Bluffs Town Beach under the provisions of Section 103 of the River and Harbor Act of 1962.

The project was adopted 7 April 1967, by the Chief of Engineers under authority of Section 103 of the River and Harbor Act of 1962, as amended. The project is shown on the project map at the end of this section.

The project was completed in October 1973, at a total cost of \$471,917 of which \$198,583 was contributed by local interests. The first cost included monies for 98,000 cubic yards of sandfill. The sandfill was obtained from a nearby land based borrow source.

Since restoration in 1973, the beach has received an extensive amount of recreational use by local residents and island tourists during the summer season. In addition, the beach has provided adequate protection to the pavilion, seawall, and backshore development in the beach area.

The beach has remained fairly stable since it was restored. The stone groin is also in a good state of repair. There has not been a need to provide any beach nourishment or groin maintenance to the project since its initial construction.



## CONSTRUCTED HURRICANE PROTECTION PROJECT

### NEW BEDFORD-FAIRHAVEN HURRICANE FLOOD PROTECTION PROJECT

This completed project had its origins as a result of the severe damages sustained from hurricanes along the eastern and southern coastal areas of the United States, in view of which the 84th Congress, 1st Session, adopted on 15 June 1955, Public Law No. 71, which authorized the Corps of Engineers to undertake a study of means to prevent the loss of human lives and damages to property from hurricane tidal flooding. As a result of this Public Law, the New England Division of the United States Army Corps of Engineers, prepared an interim hurricane survey report entitled "New Bedford-Fairhaven, Massachusetts" dated 8 February 1961.

The city of New Bedford and the town of Fairhaven, Massachusetts, are located in Bristol County, about 50 miles south of Boston, Massachusetts, and about 30 miles southeast of Providence, Rhode Island. They are situated on the west shore of Buzzards Bay which opens to the Atlantic Ocean. The town of Acushnet adjoins Fairhaven on the north.

The combined area of New Bedford, Fairhaven and Acushnet covers approximately 51 square miles of which about 20 square miles are in New Bedford, 12 in Fairhaven, and 19 in Acushnet. The three communities have a total water frontage of about 37 miles, about 18 miles of which are in the area covered in the report. The remaining 19 miles constitute the shoreline in the Sconticut Neck and West Island area of Fairhaven. Of the 18 miles discussed in the report about ten are in New Bedford, six in Fairhaven and two in Acushnet. The study area is shown on the hurricane protection project map at the end of this discussion.

The 1961 report presented the results of an examination and survey of hurricane tidal flooding in the towns of New Bedford, Fairhaven and Acushnet, exclusive of the Sconticut Neck and West Island area of Fairhaven; including recommendations as to what protection measures should be taken for the area.

The study determined that the city of New Bedford and the towns of Fairhaven and Acushnet, Massachusetts, had sustained heavy damages in the past due to flooding caused by hurricanes and would face a continuing threat of similar damages in the future. Hurricane damages were found to result chiefly from (1) saltwater flooding by the hurricane surge, (2) action of storm driven waves, (3) freshwater flooding resulting from torrential rains, and (4) the effect of high velocity winds. The report limited itself to the damages arising from saltwater tidal flooding and wave action. The study addressed itself to trying to provide protection for as great a portion of the flooded areas in New Bedford, Fairhaven and Acushnet as could be economically justified based on the resulting estimated benefits.

During the course of the study a number of plans were considered for protective structures which would reduce the damages from tidal flooding in future hurricanes. These plans are briefly described below:

a. Plan "A". A plan for a rock-faced, earth-fill barrier or causeway across the Acushnet River at Coggeshall Street, with concrete walls extending along Coggeshall Street to high ground in New Bedford and Fairhaven. A gated outlet structure, which would be operated at the time of a hurricane, is provided through the causeway to accommodate the flow of the Acushnet River.

b. Plan "B". A plan for a combined highway and hurricane protection structure across the Acushnet River, about 500 feet below Coggeshall Street, together with a combined access road and hurricane dike running southward along the west or the New Bedford shore of the river to a point just upstream of the New Bedford-Fairhaven Bridge. The highway crossing and access road would form part of an expressway plan which was being studied by the Massachusetts Department of Public Works. The hurricane protection features of Plan "B" included a 4-foot high concrete wall along the south side of the considered expressway and the east side of the access road, a gated outlet structure, and a short section of closure dike and wall running to high ground south of the terminus of the access road.

c. Plan "C". A plan for an earth and rock barrier across the Acushnet River, from the foot of Wamsutta Street in New Bedford, across Marsh Island, to high ground at the south end of Riverside Cemetery in Fairhaven. Closure to high ground in New Bedford would be accomplished by a concrete wall. A gated outlet structure would be incorporated in the barrier.

d. Plan "D". A plan for an earth and rock barrier, with gated outlet structure, across the Acushnet River from the foot of North Street in New Bedford to the north end of Popes Island, then continuing to high ground near the intersection of Pilgrim Avenue and Main Street in Fairhaven. The barrier circles the existing 30-foot deep maneuvering area north of the New Bedford-Fairhaven Bridge. A short section of concrete wall along North Street completes closure to high ground in New Bedford.

e. Plan "E". A plan for a barrier structure at the head of New Bedford Harbor, immediately south of the New Bedford-Fairhaven Bridge, consisting of sections of earth and rock dikes and concrete walls running from high ground near the intersection of Second and Middle Streets in New Bedford to high ground at Huttleston Avenue and Adams Street in Fairhaven. One considered variation in the plan of protection at this location included a gated opening for navigation to permit access to wharves above the bridge. An alternative of this plan provided for new wharf facilities along the south side of the barrier structure in lieu of a navigation opening. Under both alternatives, a gated outlet structure was provided through the barrier, near the east end of Popes Island, to permit the normal flow of the tide.

f. Plan "F". A plan for an earth and rock barrier across New Bedford Harbor in the vicinity of Palmer Island, with a dike extension along the New Bedford shore, and supplemental dikes and walls in the Clark Cove area of New Bedford and in Fairhaven. A gated opening for navigation is provided in the section of the barrier between Palmer Island and Fort Phoenix, where it crosses the existing 30-foot deep navigation channel, to permit the movement of vessels into and out of the harbor.

g. Outer Harbor Barrier. A barrier structure across the outer harbor from Clark Point, New Bedford, to Sciticut Point, Fairhaven, with either a gated or ungated opening for navigation. Under this proposal, supplemental protection would be required in the Sciticut Neck area of Fairhaven and at Clark Cove.

h. Waterfront Dikes. Protection by dikes and walls along the New Bedford and Fairhaven shores, either alone or in combination with other considered plans.

After a thorough evaluation several of the considered plans were eliminated and the final selected plan of protection designated as Plan "F" above was selected. This plan consisted of three structures. The largest and most important of these structures was the barrier across New Bedford and Fairhaven Harbor in the vicinity of Palmer Island. This barrier, in addition to preventing the entrance of hurricane tidal surges, also serves as a breakwater and protects the harbor area north of Palmer Island from the action of the high waves that occur at the time of a hurricane and other great storms.

Supplemental dikes and walls to prevent flanking of the main barrier are provided in the Clark Cove area of New Bedford and in Fairhaven. The selected alignment of the structures involved a minimum amount of land taking.

Plan "F" affords complete protection to about 1,400 acres of property in New Bedford, Fairhaven and Acushnet, below an elevation of 12.5 feet msl, that were inundated by tidal flooding in the hurricane of September 1938.

In the main harbor area, Plan "F" provides practically complete flood protection to properties behind the barrier and dike under conditions of a design hurricane surge and coincident design rainfall. The degree of protection depends upon the stage of tide when the navigation gates are closed. If the gates are closed when the tide is at or below mean sea level, the buildup in the pool behind the barrier will not reach the stage where damage begins. Closure of the gates when the tide is at a mean high water level will result in a maximum pool elevation of 5.5 feet msl. At this elevation some minor flood damage may occur. During the course of the study, an economic analysis was conducted to determine if federal participation in a hurricane protection project was justified.

Based on 1956 price levels, the first cost of the project was estimated to be \$17,200,000 of which \$15,490,000 would be borne by the United States. Local interests would be required to contribute \$1,560,000 in cash and provide lands, rights-of-way, and necessary relocations at an estimated cost of \$150,000. Unit prices were based on averaging those for similar types of projects either constructed, under construction, or under contract in New England and, where applicable, similar construction in other parts of the country. Adjustments were made for the availability and location of material required. In addition to the cost of construction materials, the first cost included monies for contingencies, engineering, design, and supervision. Adding interest during construction for a period of  $2\frac{1}{2}$  years made the total first cost equal \$17,738,000.

Based on the total first cost of \$17,738,000, the annual charges associated with the project were determined to be \$691,000. The annual cost was based on an interest rate of 2.5 percent and a fifty year project life. In addition, an allowance of \$65,000 for annual operation and maintenance, including a charge to cover the cost of major replacements in the future, was included in the annual charges.

The evaluated tangible benefits which could be attributed to the selected protection plan for the study area included tidal-flood damage prevention and elimination of "scare costs." The total average annual flood damages which would be prevented by construction of the project were estimated to be \$943,800 based on 1956 prices. This amount equals an annual loss of \$949,200 before protection is provided less estimated residual losses of \$5,400 that would be sustained even if protection is provided. Such residual damages would be incurred from ponding behind the protective works as a result of runoff from the local area and overtopping from waves. In addition to the actual tidal-flood damages, significant costs result from the institution of temporary preventive measures following a hurricane warning, whether flooding occurs or not. Included among such measures are provisions for sand-bagging and plans for the temporary evacuation of space likely to be flooded. It was estimated that "scare costs" to local commercial and industrial interests in the New Bedford-Fairhaven area would amount to about \$147,100, at 1956 prices, for each hurricane scare. Based on a frequency of three warnings every ten years, a frequency consistent with records of those for the past 50 years, average annual "scare costs" for the area would amount to \$44,100. The total evaluated annual benefits which could be credited to the protection were found to be \$987,900. During the computations of the benefits it was not possible to evaluate a variety of damages resulting from tidal flooding. Among the most significant of which were: (1) benefits accruing from the reduction of damages to pleasure craft and commercial vessels afloat, and to automobiles parked on public highways and in commercial parking lots, (2) benefits from the prevention of damages due to the destructive force of hurricane waves, as distinct from the effect of high-water levels, and (3) benefits accruing from the encouragement which protection would provide for industry and business in the survey area. In addition a substantial amount of intangible benefits would be derived from the construction of the selected plan. These included the prevention of loss of life and reductions of the danger of diseases arising from polluted flood waters and water supplies and elimination of insecurity and worry among the residents concerning unpredictable hurricane flooding. The protection project would undoubtedly stimulate all segments of the economy and improve the general welfare of the residents.

A comparison of the estimated annual benefits of \$987,900 with the estimated annual charges of \$691,000 resulted in a benefit-to-cost ratio of 1.4 indicating economic justification for federal participation in the hurricane protection project.

In the report the Division Engineer recommended that the selected plan for hurricane protection in the New Bedford-Fairhaven Harbor area, Massachusetts, designated as Plan "F", consisting principally of a

barrier across the harbor, with a gated opening for navigation, and supplemental dike and wall protection in New Bedford and Fairhaven, be authorized by the United States for construction. At the time of the study the estimated first cost to the United States was determined to be \$15,490,000 and the annual cost for operation and maintenance of the harbor barrier and gate was \$55,000.

It was further recommended that the project be authorized subject to the condition that local interests cooperate to the following extent:

- a. Provide without cost to the United States all lands, easements, and rights-of-way necessary for the construction of the project.
- b. Hold and save the United States free from damages due to the construction works.
- c. Accomplish any relocation of power cables which may be required by reason of construction of the project.
- d. Operate and maintain all land features of the project after its completion, including the Clark Cove Dike and walls, the Fairhaven dike, the dike and wall extension to the harbor barrier, extending south along the New Bedford shore from the foot of Gifford Street, and all modifications to the existing sewerage system, in accordance with regulations prescribed by the Secretary of the Army.
- e. Contribute \$1,560,000 towards the first cost of the project or, as an alternative, contract to pay annually the cost to the United States for operation and maintenance of the harbor barrier and gates, estimated at \$55,000.

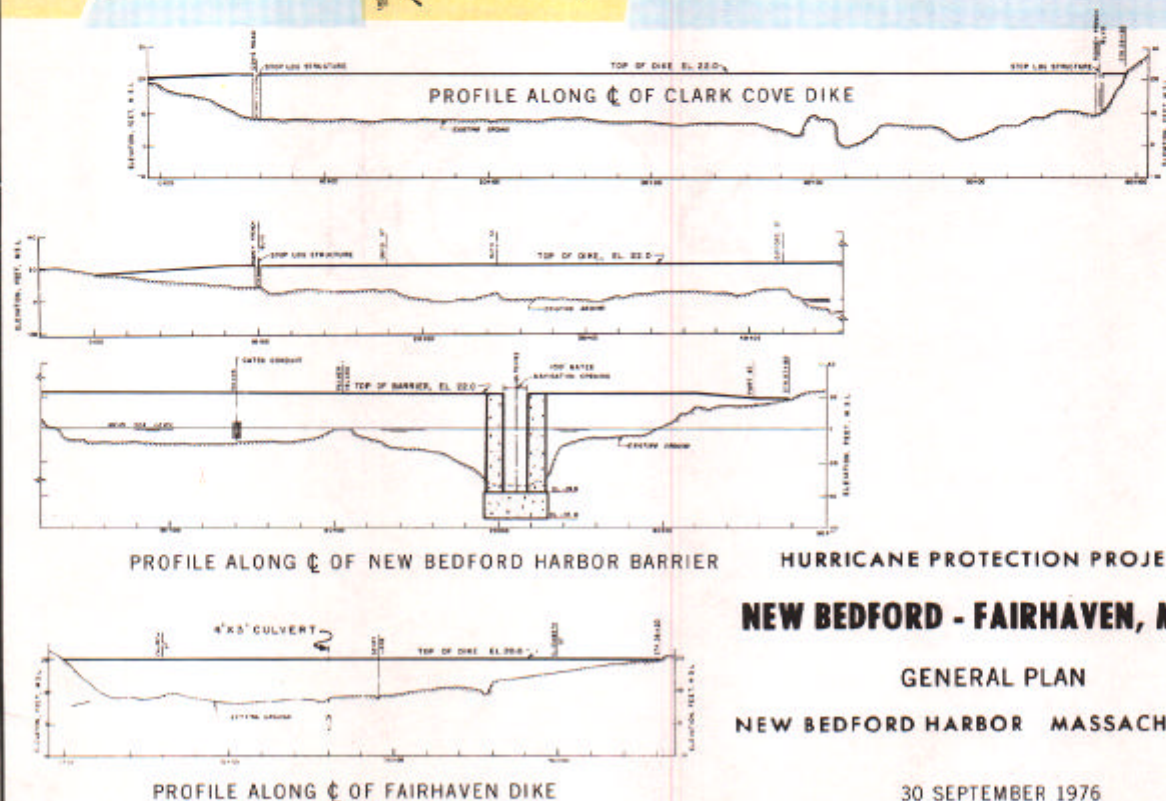
In the event the local interests elected to contract to pay annually the cost for operation and maintenance of the harbor barrier and gates by the United States, the first cost to the United States was then estimated to be \$17,050,000.

The project was authorized by the Flood Control Act of 1958. Construction of the pumping station was initiated in October 1962 and completed in June 1964. Construction of the barrier and appurtenances was initiated in October 1962 and completed in January 1966.

The total cost for construction of the project was \$18,588,700, of which \$17,972,300 was for construction and \$616,400 for lands, damages, rights-of-way, and relocations. Of this total cost the non-federal interests contributed \$7,096,600.

Since project construction in 1966 thru October of 1977, the total maintenance costs of the project have been \$1,394,481. During this same period, it has been estimated that the project has prevented approximately \$2,360,000 worth of damages. This points out how effective the project has been in serving its intended purpose.

M24a



# HURRICANE PROTECTION PROJECT NEW BEDFORD - FAIRHAVEN, MASS.

GENERAL PLAN  
NEW BEDFORD HARBOR MASSACHUSETTS

30 SEPTEMBER 1976

## AUTHORIZED BEACH EROSION CONTROL PROJECTS

### BRANT ROCK BEACH MARSHFIELD, MASSACHUSETTS

A beach erosion control study of the south shore of Massachusetts between Pemberton Point and the Cape Cod Canal in Bourne, Massachusetts was made by the Corps of Engineers, United States Army, in cooperation with the Commonwealth of Massachusetts under authority of Section 2 of the River and Harbor Act approved July 3, 1930 as amended and supplemented. A formal application for the study dated June 13, 1950 was approved by the Chief of Engineers on July 20, 1950. Brant Rock Beach, Marshfield was one of the shore areas included in the study, the results of which are contained in the report entitled "Beach Erosion Control Report on Cooperative Study of the Shore Between Pemberton Point and Cape Cod Canal, Massachusetts," dated 31 July 1957.

Brant Rock Beach is a town-owned beach located on the eastern shore of Marshfield, Massachusetts. At the time of the study the beach extended about 2,700 feet north from a jetty connecting Brant Rock and the shore. Another jetty was located at the north end of the beach and two stone groins, each about 200 feet long, were spaced approximately equally between the jetties. The beach was developed principally for recreational use during the warm summer months. Development behind the beach consisted of a paved access road, a paved parking area, a bathhouse and a concrete revetment extending along the length of the beach. The beach is shown on the attached project map at the end of this section.

At the time of the study the problem occurring at the beach was basically one of erosion of the sandy beach material leaving a coarse gravel material uncomfortable for bathing use and of insufficient width to prevent extensive damage to the backshore seawall which was constructed to protect the highway located immediately behind the beach. The erosion was principally due to wave action during storm conditions. The problem was aggravated by the lack of a suitable amount of littoral material moving around in the area to replace the material being lost by erosion.

The study determined the most feasible plan of protection and improvement for the beach would consist of the construction of a protective beach 125 feet wide at mean high water in front of the existing wall by direct placement of 110,000 cubic yards of sandfill and raising the inner 200 feet of the Brant Rock jetty to form a barrier groin.

An economic analysis was conducted during the course of the study to determine the first cost, annual charges and benefits associated with the plan of improvement to see if there was enough economic justification for Federal participation in the construction of a project.

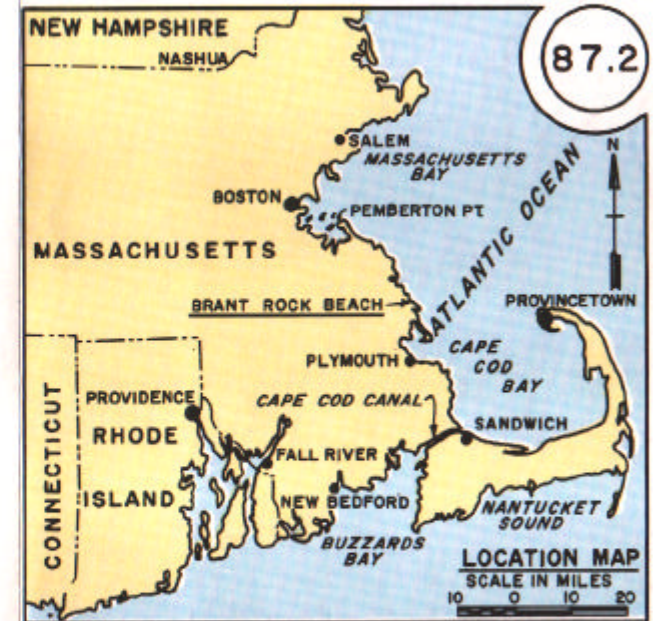
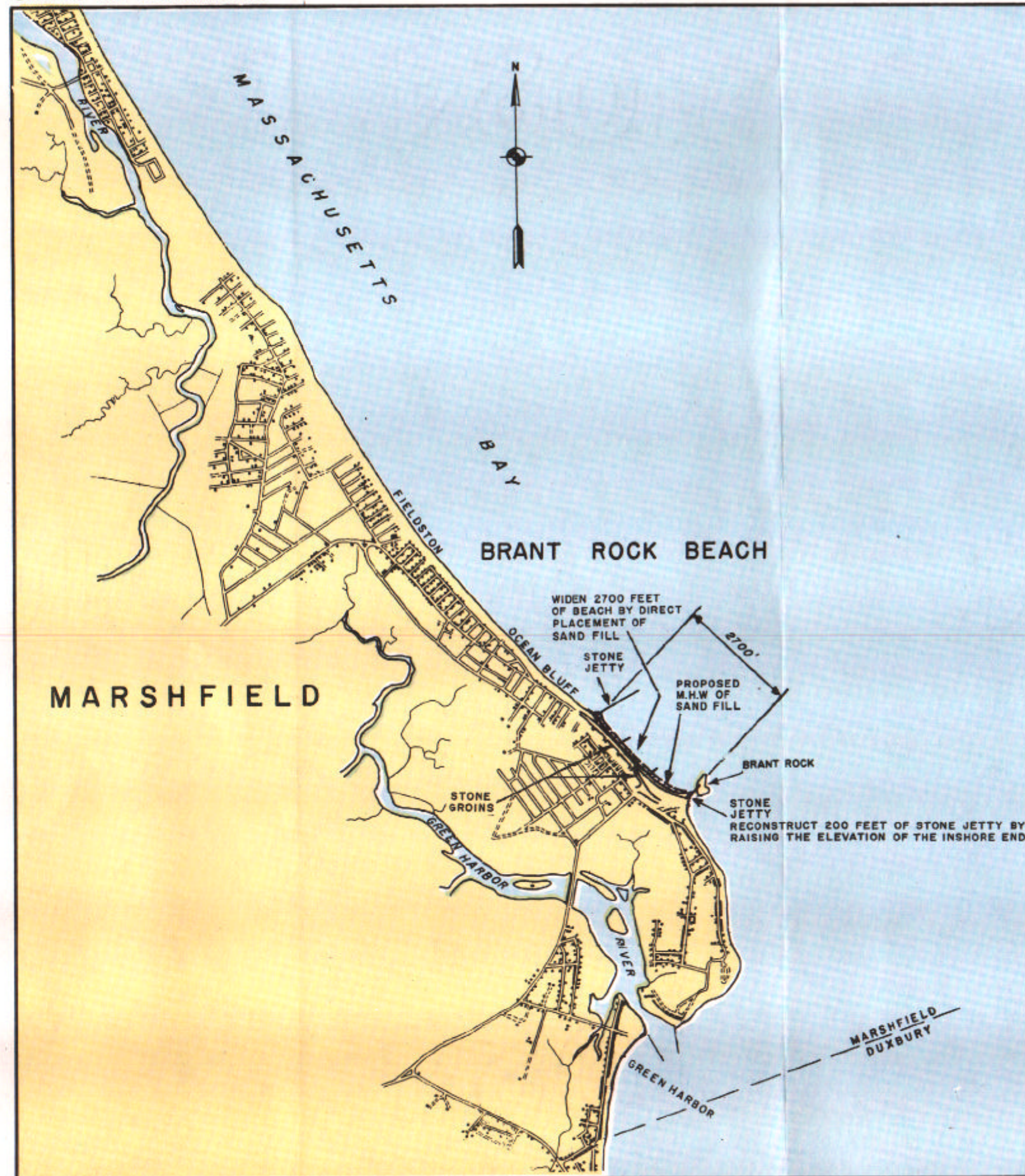
The total first cost of the project was estimated to be \$148,000 based on 1957 price levels. This estimated first cost included monies for 110,000 cubic yards of sandfill, modification work to the existing stone jetty, contingencies, engineering, design, supervision, and administration. The annual charges were established to be \$9,800 based on an interest rate of 2.5 percent for the federal investment, 3 percent for the non federal investment and a project life of 50 years.

Generally two types of benefits could be realized if a beach erosion control project was constructed. One is the elimination of direct damages to property and structures and the second is the encouragement of the healthful recreation of the public by providing additional beach area. For the Brant Rock Beach area it was felt that direct damages to backshore buildings, parking areas and streets would be eliminated if the considered project was constructed. In addition, maintenance of the existing structures would be greatly reduced or eliminated. It was determined that these damages amounted to about \$19,700 annually. No recreational benefits were developed since it was determined that the existing beach area was sufficient to accommodate the existing and future beach bathing demand.

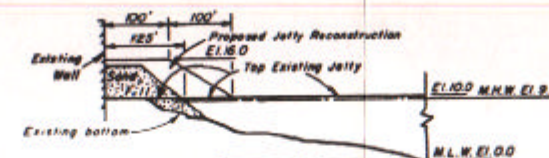
The ratio of the estimated annual benefits to the estimated annual cost was found to be 2.0 indicating economic justification for federal participation in the construction of a beach erosion control project at Brant Rock Beach.

Based on the study findings, the Division Engineer recommended in the report that the United States adopt a beach erosion control project for Brant Rock Beach authorizing federal participation in an amount equal to one-third of the first cost of construction. The federal share of the cost was estimated to be \$49,300.

The project was adopted by the River and Harbor Act of 14 July 1960 and modified by the River and Harbor Act of 1962. The 1962 act increased the allowable federal participation to an amount equal to 50 percent of the total first cost of the project. The authorized project is shown on the project map at the end of this section. No work has been initiated on the project to date.

**JETTY RECONSTRUCTION DETAILS**

TOP WIDTH 5'  
 SIDE SLOPES 1 ON 1.5  
 TOP AND SLOPE STONES, MINIMUM SIZE 1.5 TONS  
 SAND TIGHT CORE OF QUARRY RUN STONE  
 UP TO 150 LBS. IN WEIGHT

**PROPOSED JETTY RECONSTRUCTION**

**SCALE IN FEET**

**0 100 200**

**VER. 10 0 10 20**

**INCOMPLETED WORK**

**BRANT ROCK BEACH**  
**MARSHFIELD, MASS.**

**30 SEPTEMBER 1978**

**IN 1 SHEET**

**SCALE IN FEET**

**0 1000 2000 3000**

**DEPARTMENT OF THE ARMY**  
**NEW ENGLAND DIVISION, CORPS OF ENGINEERS**  
**WALTHAM, MASS.**

CLARK POINT  
NEW BEDFORD, MASSACHUSETTS

A study was made by the Corps of Engineers, United States Army, in cooperation with the city of New Bedford, Massachusetts, under authority of Section 2 of the River and Harbor Act approved July 3, 1930, as amended and supplemented. Formal application for the study was made by the city on 5 March 1958 and approved by the Chief of Engineers on 1 April 1958.

The study was undertaken to determine the best method of restoration and stabilization of the city beaches along Rodney French Boulevard East and West which are located on both sides of the Clark Point Peninsula. The results of the study are contained in the report entitled "Beach Erosion Control Report on Cooperative Study of Clark Point, New Bedford, Massachusetts," dated 11 May 1961, prepared by the New England Division of the U.S. Army Corps of Engineers.

The city of New Bedford is located in Bristol County, Massachusetts, about 50 miles south of Boston, and about 30 miles southeast of Providence, Rhode Island, on the north shore of Buzzards Bay, an arm of the Atlantic Ocean. The Clark Point Peninsula is a glacial deposit projecting about 2 miles southerly into Buzzards Bay. It is bounded on the west by Clark Cove and on the east by a larger cove at the entrance to New Bedford - Fairhaven Harbor. The area is shown on the project map at the end of this section.

At the time of the study most of the northerly portion of the east coast of Clark Point was publicly owned except for about 323 feet between Aquidneck and Apponagansett Streets and about 250 feet south of and adjacent to Aquidneck Street. South of this area a number of private residences were located on the seaward side of Rodney French Boulevard East and they were fronted by 3 small groins and a narrow sandy beach. South of this residential area the city built a public beach in 1959. This beach was created by the placement of sandfill between 5 groin structures which were built along the 2,400 feet of shorefront. South of this area at the tip of Clark Point was occupied by Fort Rodman, a federal military reservation. This reservation contained about 5,000 feet of shoreline, north of Fort Rodman for about 3,500 to Lucas Street the beach was found to be extremely narrow, gravelly and steep. This stretch of beach is publicly owned and the city's screening and pumping plant for storm and sanitary sewage is located on it. From Lucas Street northerly to Dudley Street, a distance of about 1,600, a well developed city beach was located on the seaward side of Rodney French Boulevard West. The beach consisted of short sand fillets at groins which was all that remained of the artificially placed sandfill.

The problem occurring along the shore of the Clark Point Peninsula at the time of the study was generally one of erosion of the beaches and damage to structures protecting facilities and Rodney French Boulevard East and West which parallel the shore around the peninsula. In the past the city had experienced difficulty in maintaining an adequate public bathing beach along Rodney French Boulevard West due to the rapid loss of beach material by wave action. The situation was aggravated by the fact that natural sources of supply had been largely eliminated by the construction of the seawalls and other protection works along the shore of the peninsula and the erosion of the finer sandy materials from adjoining shore areas leaving a mantle of coarse material.

A number of measures were considered to help stabilize and restore the shoreline during the course of the study. Consideration was given to widening the beaches to protect the shore and Rodney French Boulevard East and West. This would also provide additional recreational beach along the east and west shores of Clark Point north of Fort Rodman, as needed. It was felt that reduction of high losses of beach material from the beaches could be effected by new groin construction or by lengthening of existing groins. Maintenance of seawalls in areas where there is an inadequate width of protective beach could be affected by the use of stone revetment along the toe of the concrete wall bordering Rodney French Boulevards. It was felt the existing bathing beach along the east shore could probably be maintained adequately by periodic nourishment to replace losses of beach material.

Two plans of protection and improvement of approximately 1,600 feet of beach along Rodney French Boulevard west between the groin at Dudley Street and the ramp at Lucas Street were developed during the course of the study. The first plan consisted of reconstructing the inshore end of the Dudley Street groin to a higher elevation, lengthening the two existing groins south of Dudley Street and widening the beach by direct placement of sandfill.

The second plan consisted of reconstructing the inshore end of the Dudley Street groin to a higher elevation, constructing three additional groins with approximately the same length and at one-half the spacing of the existing groins and widening the beach by direct placement of sandfill.

The fill would be placed generally to widen the beach above mean high water to a minimum width of 100 feet to provide protection against wave attack and to provide additional beach area for recreational use. It was felt the groin reconstruction, construction or extensions would reduce losses of beach material. During the study it was determined that suitable material for beach fill from land borrow areas was available west and north of the harbor.

Also during the course of the study a plan of protection and improvement was developed for a portion of the beach along Rodney French Boulevard East between Aquidneck Street and Apponagansett Street for possible future use by local interests. The plan consisted of widening the beach by direct placement of sandfill generally to a width of 100 feet at mean high water and construction of groins to retain and reduce losses of the fill. It was felt that there would not be enough benefits associated with this plan to warrant federal participation.

An economic analysis was made during the course of the study to determine if federal participation and cost sharing was feasible for any of the considered plans of improvement. An economic life of 50 years was used in determining interest and amortization charges. A directed interest rate of 2 5/8 percent was used in establishing the federal annual charges and 3.5 percent for the non-federal charges. The first cost for beach construction was based on dry borrow and truck haul to the site. Annual maintenance requirements for beach fill were estimated from losses that had been experienced in the past.

For the beach along Rodney French Boulevard West two plans of improvement and protection were developed. The estimated first cost of the plan involving extension of the existing groins was determined to be \$180,000 and the associated annual charges was determined to be \$20,200. This first cost included monies for 5,500 tons of stone, 68,000 cubic yards of sandfill, contingencies, engineering, design, supervision and administration. The annual charges contained provisions for annual beach nourishment of 11,000 cubic yards and 55 tons of stone for groin maintenance.

The estimated first cost of the second plan of improvement involving new groin construction for the beach along Rodney French Boulevard West was determined to be \$126,000 and the associated annual charges were found to be \$18,500. The first cost included funds for 9,400 tons of stone, 36,000 cubic yards of sandfill, contingencies, engineering design, supervision and administration. The annual charges contained monies for 11,000 cubic yards of sandfill and 94 tons of rock.

An estimate of the first cost and associated annual charges were developed for the plan of improvement of the beach along Rodney French Boulevard East. These figures were developed for use by local interests since it was assumed there would be no federal participation in such a project. The first cost was determined to be \$97,000 and the associated annual charge was found to be \$10,000. The first cost included funds for 5,900 tons of stone, 36,000 cubic yards of sandfill, contingencies, engineering, design, supervision and administration. The annual charges contained provisions for 4,800 cubic yards of sandfill for beach nourishment and 60 tons of rock for groin maintenance.

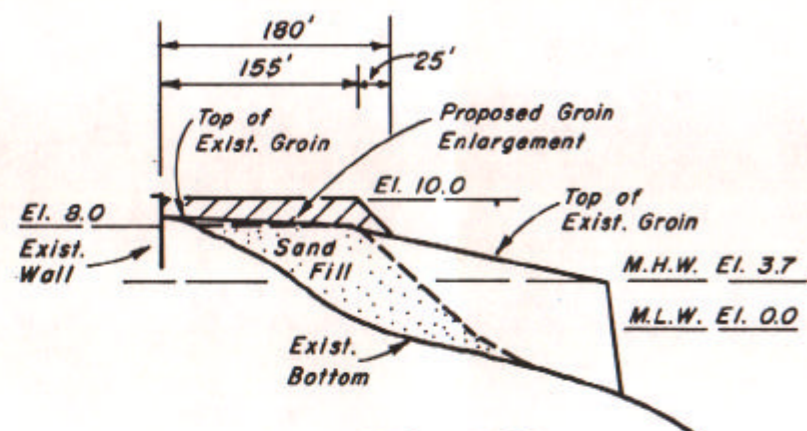
The benefits which would be derived if an improvement project was constructed for the beach area along Rodney French Boulevard West would be based on the promotion and encouragement of the healthful recreation of the populace, prevention of direct damages to existing structures and prevention of the loss of land. No benefits were developed for the plan of improvement of the beach along Rodney French Boulevard East. For the plan of improvement for Rodney French Boulevard West involving the groin extension the total annual benefits were found to be \$38,925. For the new groin construction plan the total annual benefits were estimated to be \$35,440.

The ratio of the estimated annual benefits to the estimated annual cost was found to be 1.93 for the groin extension plan and 1.92 for the new groin construction plan. Both of these indicate there was economic justification for federal participation in the construction of a beach erosion control project for the beach along Rodney French Boulevard West.

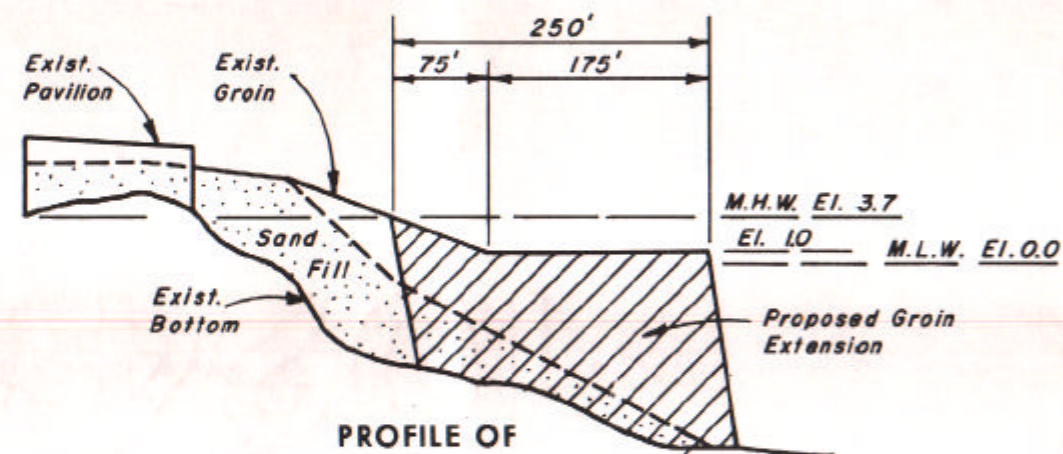
In the report the Division Engineer recommended that the United States adopt either one of the beach erosion control projects for the beach along Rodney French Boulevard West. He further recommended that the United States should authorize federal participation by the contribution of federal funds in an amount equal to one-third of the first cost of construction. The estimated amount of federal participation for initial construction of the groin extension plan was determined to be \$60,000 and for the new groin plan it was found to be \$42,000. The groin extension plan is shown on the project map at the end of this section.

The project was adopted by the River and Harbor Act of 23 October 1962. This act provided for federal participation in the amount of one-half of the first cost of measures for restoration and protection of the shore at Rodney French Boulevard West Beach, New Bedford, consisting of widening approximately 1,600 feet of beach to a minimum berm width of 100 feet; raising the inshore end of the existing groin at Dudley Street, and extending existing town groins at and south of Valentine Street, 250 and 85 feet respectively.

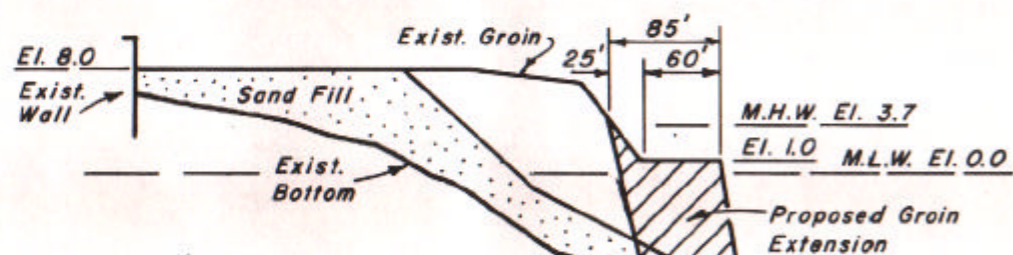
No work has been done on the authorized project to date. However, at the present time the city is developing plans for the protection and improvement of the west shore of Clark Point, including the authorized federal project area. The city expects to incorporate the federal project in with their plans in order to get federal cost sharing for a portion of the work.



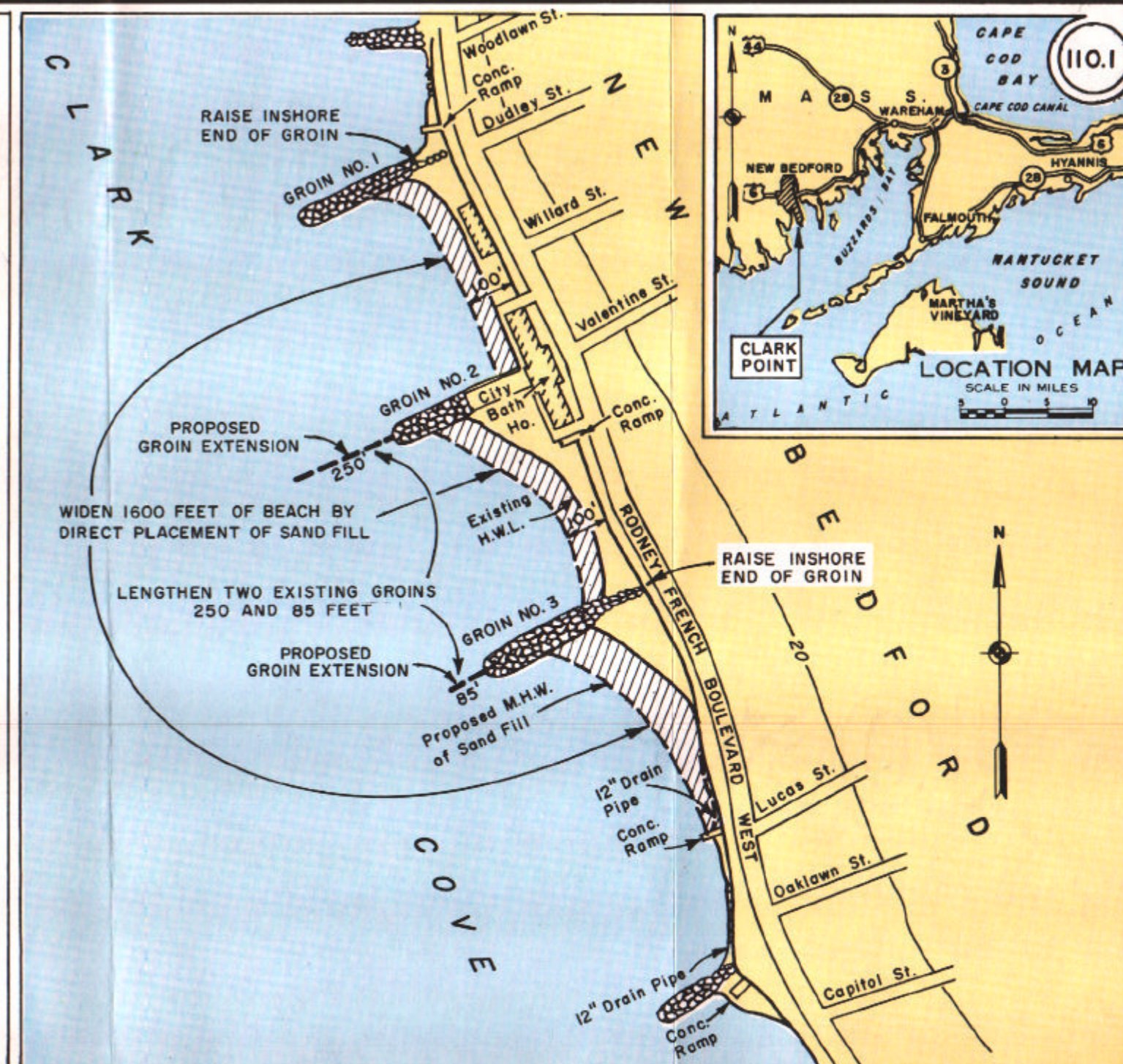
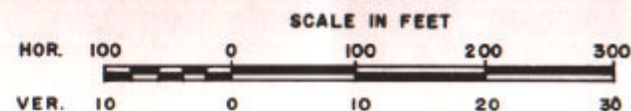
PROFILE OF  
PROPOSED GROIN ENLARGEMENT AND SAND FILL  
GROIN NO. 1



PROFILE OF  
PROPOSED GROIN EXTENSION AND SAND FILL  
GROIN NO. 2



PROFILE OF  
PROPOSED GROIN EXTENSION AND SAND FILL  
GROIN NO. 3



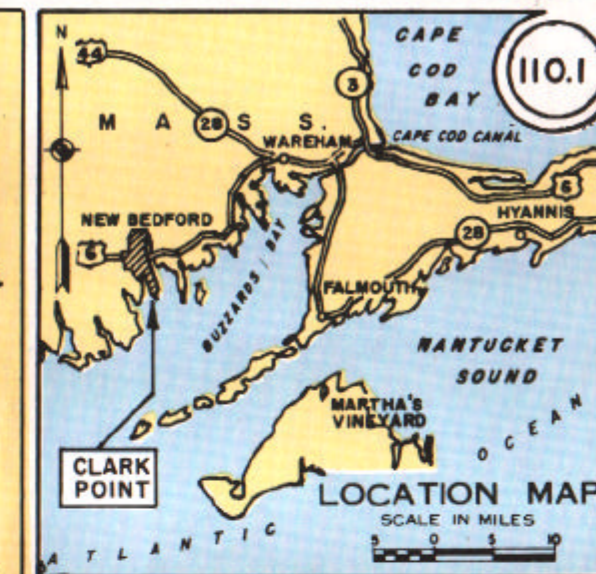
#### FILL SLOPE (Approximate)

1 on 11 above -1.0  
1 on 20 below -1.0

#### GROIN DETAILS

Top width 5'  
Side slopes 1 on 1.5  
Cap and Slope Stones,  
minimum 1.5 tons for trunk  
and 2.0 tons for head of groin  
Sand tight core of quarry run stone

INCOMPLETED WORK



#### CLARK POINT NEW BEDFORD, MASS.

30 SEPTEMBER 1978

IN 1 SHEET  
SCALE IN FEET  
100 0 100 200 300

DEPARTMENT OF THE ARMY  
NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
WALTHAM, MASS.

LYNN - NAHANT BEACH  
MASSACHUSETTS

A formal application from the Metropolitan District Commission of the Commonwealth of Massachusetts, dated August 9, 1945, for a cooperative study of beach problems within the Metropolitan District in the vicinity of Boston, Massachusetts, including Lynn-Nahant Beach, Revere Beach, Winthrop Beach, Quincy Shore Beach and Nantasket Beach, and providing for prosecution jointly by the Metropolitan District Commission and the United States was approved by the Chief of Engineers, United States Army, October 2, 1945, in accordance with the authority conferred by the provisions of Section 2 of the River and Harbor Act approved July 3, 1930 and Public Law 166, 79th Congress, approved July 31, 1945.

Lynn-Nahant Beach is one continuous beach comprising King's Beach Reservation in the town of Swampscott, Lynn Shore Reservation in the city of Lynn, and Nahant Beach Parkway in the town of Nahant, all in Essex County, Massachusetts. The beach is  $7\frac{1}{2}$  miles north of the main entrance channel to Boston Harbor and 9 miles northeast of the city of Boston. The results of the study for this beach are contained in the report entitled "Beach Erosion Control Report on Cooperative Study of Metropolitan District Commission Beaches, Massachusetts, Part A, Lynn-Nahant Beach" dated 1 June 1949. The study area is shown on the project map at the back of this section.

Lynn-Nahant Beach comprises a bayhead beach and tombolo forming the head of Nahant Bay, and extends a distance of 2 -  $\frac{3}{4}$  miles between two headlands, Blaney Rock on the north and Little Nahant on the south. The portion of the beach in Swampscott called King's Beach Reservation and in Lynn called Lynn Shore Reservation front a moderately high coastal cliff. At the time of the study the coast was highly developed, being a better than average year-round residential area, with many large houses fronting Lynn Shore. The area also contained high-rise type apartment hotels. The residential area extended inland for over a half mile to the center of Lynn.

The MDC Reservations in Lynn and Swampscott consisted of a narrow public beach, a seawall, a wide promenade, a grass plot of varying width along Lynn shore and a wide boulevard. The beach was generally found to contain hardpacked sand which extended to the base of the wall. In the center of Lynn Shore Reservation, there is a large ledge outcrop called Red Rock. South of Red Rock the beach material was found to be coarser and contain some stone and a few boulders.

The portion of the beach in Nahant, called Nahant Beach Parkway, is the seaward face of a tombolo connecting the former island of Little Nahant to the mainland. The width of the tombolo in the area studied

averaged about 350 feet and separates Lynn Harbor from the sea. Several refreshment stands, playground areas and a state-operated public bathhouse were located at the north end of the tombolo. The entire tombolo is under control of the MDC. A continuous paved parking area is located along the center of the tombolo and on the seaward side of the parking area, a low sand dune is located, the crest of which is traversed by a paved bridle path. The backshore of the seaward beach was found to contain medium hard-packed sand and the foreshore hard-packed sand with considerable small stone in the north central area.

The formation of Lynn-Nahant Beach is the result of erosion of mainland headlands and of the former island of Little Nahant, and deposition of wave transported materials from other sources, by which the island was tied to the mainland. This process did not leave any shoals or bars in front of the beach. The beach is paralleled for its entire length by excellent public highways separated from the beach proper by public walks and promenades. Public parking is provided for the entire length of the beach. The mainland coast of the area under study is continuously protected by concrete and masonry seawalls. With the exception of the walls on the outer end of Blaney Rock in Swampscott, which are privately owned, all seawalls along the coast are owned by the MDC. The base of the dune along the Nahant tombolo was partially protected by riprap placed by the MDC. The base of Little Nahant was protected by privately-owned seawalls except in the areas where the exposed ledge afforded a natural bulwark against the sea.

At the time of the study it was found that the mainland seawalls had protected the coastal cliff from any severe damage and that there was constant erosion at the base of the wall. The wall historically has suffered from continuous spalling, disintegration and breaking of concrete and in spite of periodic and extensive repairs was found to generally be in poor condition. Erosion of the beach at the base of the wall had necessitated the construction of toe walls to prevent undermining. The tombolo area of Nahant Beach was found to be generally stable.

The MDC's objective in the study was to determine the best method for preventing further erosion, stabilizing and improving the beaches and protecting the seawalls. The study of the problems at Lynn-Nahant Beach resolved itself into three separate parts as follows:

- a. Corrective measures to be applied to the existing mainland seawalls.
- b. Improvement of the beach adjacent to the bathhouse.
- c. Protection of the tombolo.

Since the mainland seawall was found to provide adequate protection to the coast it was determined that restoration of the face of the wall and providing protection against undermining was the most feasible way to assure its continued effectiveness.

Restoration of the face of the wall would require a complete new armoring which would cover the existing surface, thereby filling all holes and cracks and protecting the present weakened surface from further damage. This armor could be provided by facing the wall with stone blocks, by casting a new reinforced concrete surface or by applying a dense concrete over the structure by the airgun method, commonly termed, "guniting". It was determined that armoring the face of the wall could be accomplished most satisfactorily and economically with reinforced concrete. In order to guard against undermining of the wall and ensure its continued stability, consideration was given to the placement of artificial fill or stone riprap in front of the wall or the use of toe walls. It was felt that using riprap would greatly reduce the already limited beach area above mean high water and that there was not enough economic justification for the placement of the large amount of artificial fill that would be required. The use of piling had already been proven on several areas of the beach as an effective means of erosion control. It was determined a steel sheet-pile toe cut-off wall would be the most suitable and economical measure to use to help stabilize the seawall.

Improvement of the beach in the area of the existing bathhouse would best be accomplished by placement of artificial fill built to an elevation of 18.0 feet above mean low water at the backshore seawall. The fill would provide a dry beach 150 feet wide above mean high water. Groins were not found to be required to maintain the fill due to the fact that the existing conditions indicated there was no net transport of littoral drift in the area. It was felt it would be better to include a permanent maintenance program so that any eroded materials may be periodically replaced. It was determined at the time of the study that suitable fill could be obtained and truck hauled from pits located from 12 to 25 miles from the beach. Offshore material in the immediate area was not felt to be suitable to be used as beach fill.

Protection of the Nahant Beach tombolo was found to be dependent on maintenance of the sand dune to prevent storm waves from breaching it. It was felt that this type of protection could be provided only by a self-supporting barrier erected seaward of the dune. A protection plan was developed involving the construction of a free standing stone mound at the toe of the dune with fill placed between the mound and the dune. The stone mound was selected because of its flexibility in meeting foundation conditions, the ease of construction and the fact that the existing riprap at the northern part of the tombolo could be utilized. It was estimated that sufficient materials could

be obtained from the required excavations to accomplish all filling required in back of the mound. The mound would prevent loss of sand from wave attack, prevent breaching of the tombolo, help increase the size of the dunes protecting Nahant Road and would not be subject to wave attack except under extreme storm conditions.

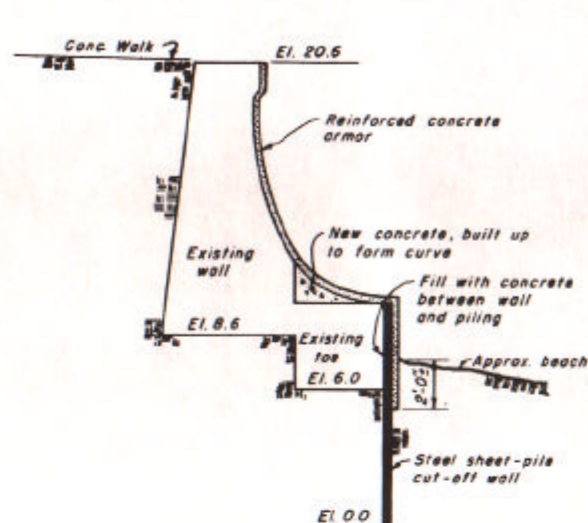
An economic analysis was prepared during the course of the study giving estimates of first costs annual charges and annual benefits for all the plans of improvement and protection which were recommended for the area between Woodbury's Point and Little Nahant. A detailed economic study was not prepared for the work recommended between Woodbury's Point and Blaney Rock, because the work comprises maintenance of existing structures and no federal participation is involved. It was felt however, that the storm damage which would be prevented and the value of the public and private property to be maintained through the repairs of the seawall would be sufficient to justify the accomplishment of the recommended repairs by local interests.

The estimated first cost of the plan of protection and improvement for the beach in the area of the bathhouse was determined to be \$366,000. This figure included the cost of 172,000 cubic yards of sandfill and monies for engineering and contingencies. For the Nahant Beach tombolo the estimated first cost of the plan of protection was determined to be \$96,000 based on 1949 price levels. This included costs for excavation, stone, rehandling of existing riprap, engineering and contingencies. The annual charge associated with the estimated total first cost of \$464,000 based on a directed interest rate of 3% for federal costs and 3½% for non-federal costs and a 40-year project life was determined to be \$28,020. This annual charge contained provisions for an estimated 3,000 cubic yards of periodic sand nourishment and stone mound maintenance.

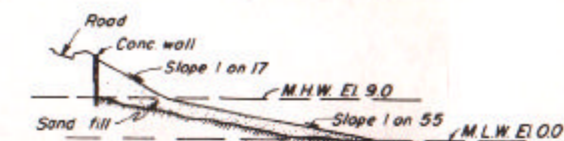
The estimated benefits which would probably accrue if the recommended plans of improvement were constructed in the area of Lynn - Nahant Beach lying between Woodbury's Point and Little Nahant would result from direct damage prevention and increased recreational use of the beach. Other intangible benefits such as indirect damage prevention, increased property values and prevention of isolation of an entire town would also be realized but it is not possible to place an exact monetary value on such benefits. It was estimated that the annual benefits which would be derived would amount to \$41,770. The ratio of the evaluated benefits to annual cost was found to be 1.5 to 1. This indicated there was economic justification for federal participation in the construction of a beach erosion control project at Lynn-Nahant Beach.

Based on the findings of the study the Division Engineer recommended in the report that a beach erosion control project be adopted by the United States for the shore between Woodbury's Point and Little Nahant by authorizing participation through the contributions of federal funds in an amount equal to one-third of the first cost of construction of the project. The estimated amount of the federal contribution was determined to be \$154,670.

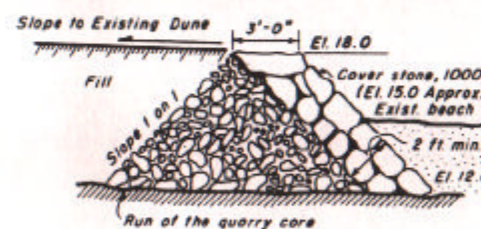
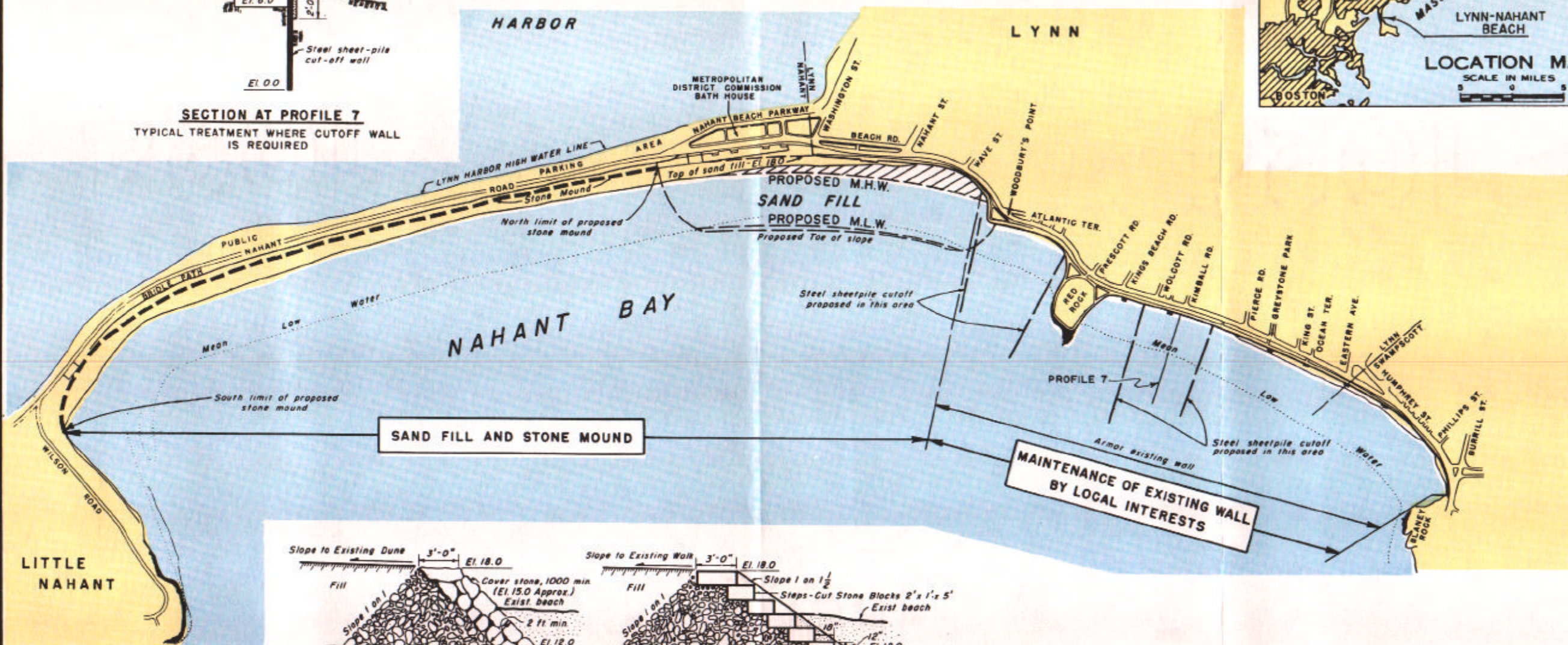
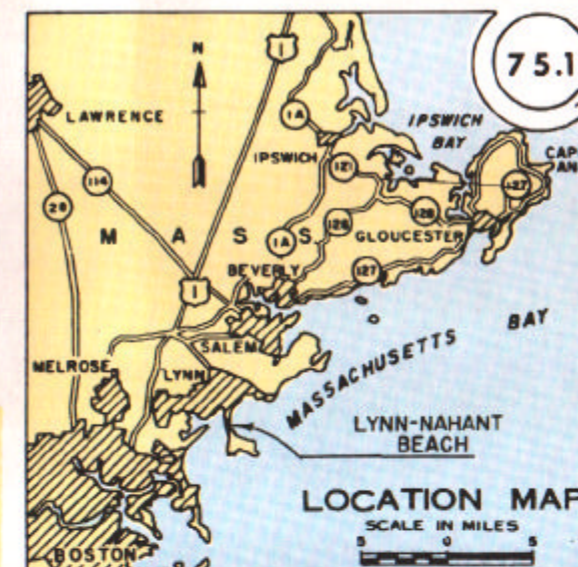
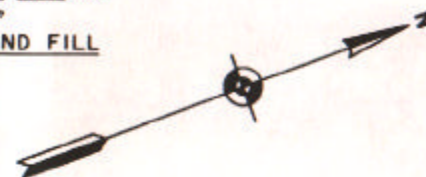
The project was adopted by the River and Harbor Act of 3 September 1954. Recomputation of the federal share was authorized by the River and Harbor Act of 23 October 1962. The federal contribution for participation in the artificial placement of 172,000 cubic yards of sand on the beach for a distance of 2,000 feet south of Woodbury's Point is now authorized in the amount of one-half of the first cost for the portion north of Washington Street and 70% of the first cost south of Washington Street. Federal participation is also authorized in the amount of 70% of the first cost of construction of a stone mound with a top elevation of 18 feet above mean low water from the south limit of the sandfill to Little Nahant. A drawing of the authorized project is shown on the project map at the end of this section. No work has been done on the existing authorized project to date.



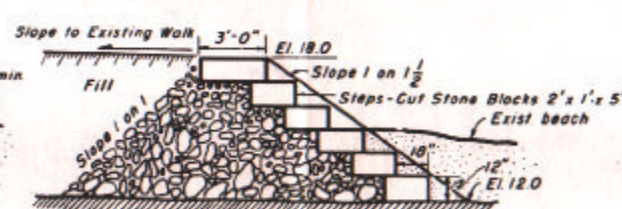
**SECTION AT PROFILE 7**  
TYPICAL TREATMENT WHERE CUTOFF WALL  
IS REQUIRED



TYPICAL PROFILE OF PROPOSED SAND FILL



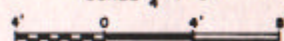
TYPICAL SECTION



STEP SECTION

DETAILS OF STONE MOUND

SCALE  $\frac{1}{4}$ " = 1'-0"



**NOTE**

Steps required at 23  
locations to provide  
access to fireplaces and  
tables at base of sand  
dunes.

INCOMPLETED WORK

**LYNN - NAHANT BEACH  
MASSACHUSETTS**

30 SEPTEMBER 1976

IN 1 SHEET SCALE IN FEET



DEPARTMENT OF THE ARMY  
NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
WALTHAM, MASS.

NANTASKET BEACH  
HULL, MASSACHUSETTS

A cooperative beach erosion control report entitled "Beach Erosion Control Report on Cooperative Study of Metropolitan District Commission Beaches Massachusetts, Part D, Nantasket Beach" was completed on 1 June 1949. The report was prepared by the New England Division, Corps of Engineers, Department of the Army, in cooperation with the Commonwealth of Massachusetts (acting through the Metropolitan District Commission).

The initial study determined that Nantasket Beach was relatively stable, that the seawalls afforded adequate protection to the area, that serious storm damage had not been experienced in the area and that the beach was suitable for recreational use with the exception of the stones deposited on the backshore area which impeded such use. It was determined that the stones are the result of the reworking of existing beach materials, and their occurrence couldn't be prevented. Based on the study findings it was recommended by the Division Engineer in the report that the United States should not adopt a beach erosion control improvement project for Nantasket Beach. It was further recommended that the best method of achieving the desired objective of improving the beach area could be accomplished by local interests by establishment of a continuous maintenance program under which the stones being deposited could be buried or removed, as conditions warranted.

A second beach erosion control study of Nantasket Beach, Hull, Massachusetts was made by the Corps of Engineers, United States Army, in cooperation with the Commonwealth of Massachusetts under authority of Section 2 of the River and Harbor Act, approved 3 July 1930, as amended and supplemented. The formal application for the study dated 22 August 1961 was approved by the Chief of Engineers on 19 September 1961. The results of that study are contained in the report entitled "Beach Erosion Control Report on Cooperative Study of Revere and Nantasket Beaches Massachusetts" dated March 1968.

This second report reviewed the information contained in the original report, the problems associated with the beach in 1968 and assessed the need for providing a beach erosion control project for the area. The purpose of the study was to review the problems at Nantasket Beach in order to determine the best method or methods of restoring and stabilizing the beach and protecting the backshore development.

Nantasket Beach is a state owned beach in the town of Hull, Massachusetts, about 4 miles southeast of the main entrance to Boston Harbor and 12 miles southeast of the city of Boston. The beach is shown on the attached project map at the end of this section.

At the time of the study 6,800 feet of the beach area was developed for recreational use. The problem was basically one of erosion and recession of the shoreline due to wind, wave, tidal and current action in the area. The problem was also found to be aggravated by the construction of protective structures along the adjoining shoreline which have helped to reduce the supply of littoral drift which formerly helped to nourish the shoreline. In addition, these structures have helped to accelerate the erosion in front of them by reflecting the large waves during storm conditions.

At the time of the study the development behind the beach consisted of a concrete seawall, a highway, a parking area, a bathhouse, a pavillion, a concert hall and a sanitary facility. Protective structures included massive concrete walls and wooden bulkheads. Nantasket Beach was also faced with a deficiency of replenishment material as a result of previous structures, since removed, causing erosion of this material under storm conditions.

The study determined the most feasible plan of protection and improvement for the beach would consist of widening the beach to a general width of about 190 feet behind the mean high water line, to a backshore elevation of 17 feet above mean low water. The widening of the beach would take place along the entire 6,800 feet of beach.

An economic analysis was conducted during the course of the study to determine the first cost, annual charges and benefits associated with the plan of improvement to determine if there was enough economic justification for federal participation in the construction of a project. The total first cost of the project was estimated to be \$2,000,000 based on prevailing 1968 price levels. This estimated first cost included monies for placement of sandfill, contingencies, engineering, design, supervision and administration. The annual charges were established to be \$131,400 based on an interest rate of 3½% for the federal and non-federal investment and a project life of 50 years. The annual charges contained provisions for 20,000 cubic yards of sandfill for periodic nourishment which was about three times the rate of erosion that had occurred for the period from 1945 to 1963.

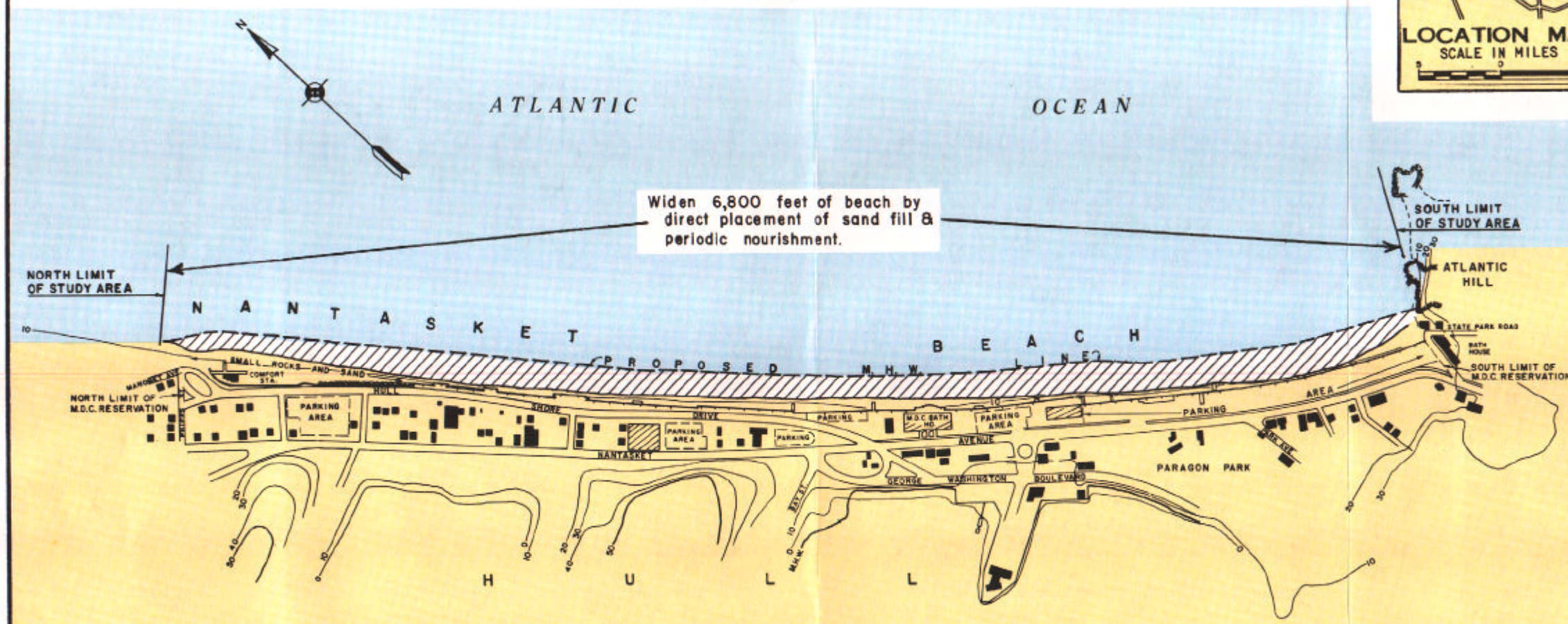
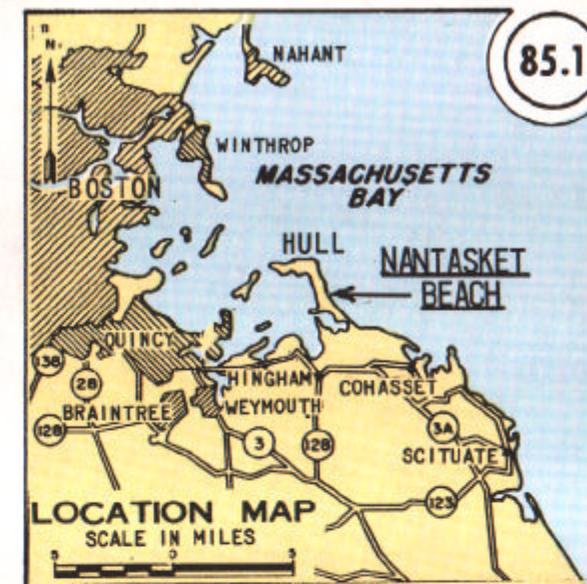
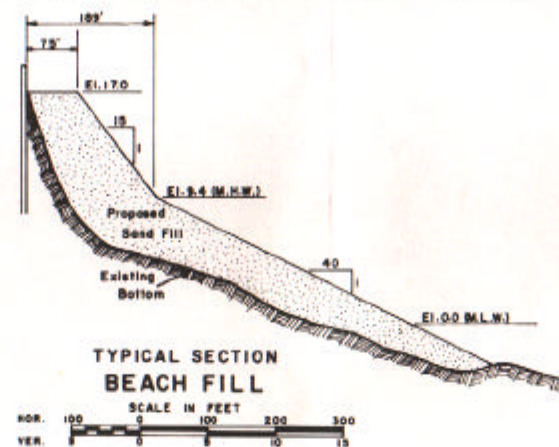
The two types of benefits that would be realized if the project were constructed are elimination of direct damages and increased recreational use of the area. The direct damages which would be eliminated included loss of land, buildings, seawall, parking area, streets and recreational facilities. In addition maintenance of the existing structures would be greatly reduced or eliminated. The recreational benefits would be derived from increased use of the improved bathing area. The total annual benefits for Nantasket Beach were estimated to be \$417,250.

The ratio of the estimated annual benefits to the estimated annual cost was found to be 3.2 indicating economic justification for federal participation in the construction of a beach erosion control project at Nantasket Beach.

Based on the study findings the Division Engineer recommended in the report that the United States adopt a beach erosion control project for Nantasket Beach authorizing federal participation in an amount equal to 50% of the first cost of construction which was estimated to be \$2,000,000, or a cost of \$1,000,000 for the federal interests.

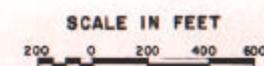
The existing project was authorized by House and Senate Resolutions adopted 15 December 1970 and 17 December 1970, respectively. The authorized project is shown on the project map at the end of this section. To date, no work has been done on the authorized project.

85.1



# NANTASKET BEACH, HULL, MASS.

30 SEPTEMBER 1976



DEPARTMENT OF THE ARMY  
NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
WALTHAM, MASS.

||||| INCOMPLETED WORK

PROVINCETOWN BEACH  
PROVINCETOWN, MASSACHUSETTS

A beach erosion control study of the north shore of Cape Cod from the Cape Cod Canal in Sandwich to Provincetown, Massachusetts was made by the Corps of Engineers, United States Army, in cooperation with the Commonwealth of Massachusetts under authority of Section 2 of the River and Harbor Act approved July 3, 1930, as amended and supplemented. The formal application for the study dated June 10, 1957 was approved by the Chief of Engineers on June 19, 1957. One of the shore areas included in the study was Provincetown Beach, Provincetown, Massachusetts. The results of that study are contained in the report entitled "Beach Erosion Control Report on Cooperative Study of Cape Cod Canal to Provincetown Massachusetts" dated 2 October 1959.

At the time of the study Provincetown Beach was a state owned beach located on the northwest shore of Provincetown, Massachusetts at the entrance to Cape Cod Bay. The beach is shown on the attached project map at the end of this section. About 4,000 feet of the beach area was developed for recreational use. Of this total only about 1,600 feet of the shoreline at the southerly end was experiencing a problem.

The problem was basically one of gradual erosion and recession of the shoreline due to wind, wave, tidal and current action in the area. The problem was also found to be aggravated by the construction of protective structures along the adjoining shoreline which have reduced the supply of littoral drift that formerly helped to nourish the shoreline.

At the time of the study the development behind the beach consisted of a paved access road, a paved parking area, a bathhouse and a snack bar. Protective structures included a bituminous revetment extending from road level to the beach north of the bathhouse and four stone groins each about 100 feet long fronting the bathhouse.

The study determined the most feasible plan of protection and improvement for the beach would consist of construction of 2 new groins, 340 feet in length, raising and extending the existing groins to a length of 380 feet, construction of 1,200 feet of precast concrete seawall in front of the bathhouse and parking area and direct placement of about 120,000 cubic yards of sandfill along the southerly 1,600 feet of the beach area.

It was felt that the project should be constructed in stages. Initially the seawall and groins would be constructed. If after the groins were constructed it was found that the littoral drift in the area was insufficient to fill in between the groins naturally, then the sandfill should be placed.

An economic analysis was conducted during the course of the study to determine the first cost, annual charges and benefits associated with the plan of improvement to determine if there was enough economic justification for federal participation in construction of the project. The total first cost of the project was estimated to be \$264,000 based on 1959 price levels. This estimated first cost included monies for 120,000 cubic yards of sandfill, 21,500 tons of stone for groin construction and alteration, 950 cubic yards of concrete for the seawall, contingencies, engineering, design, supervision and administration. The annual charges were established to be \$12,100 based on an interest rate of 2.5 percent for the federal investment, 3 percent for the non-federal investment and a project life of 50 years.

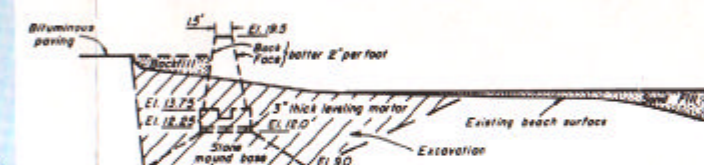
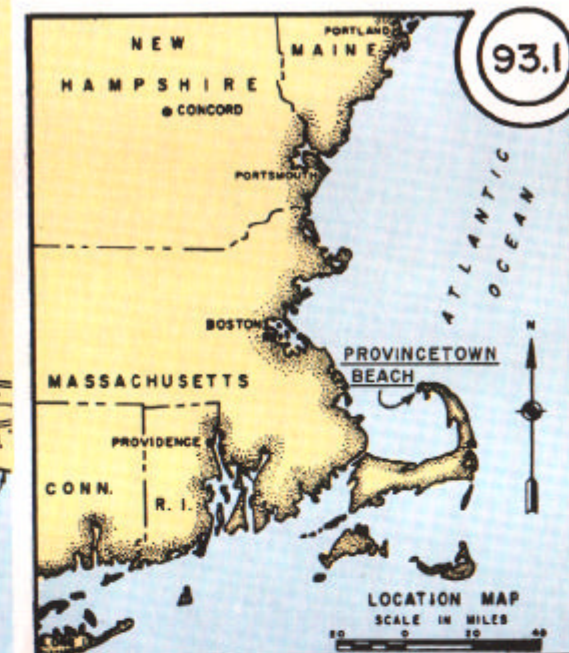
The two types of benefits that would be realized if the project were constructed are elimination of direct damages and increased recreational use of the area. The direct damages which would be eliminated include loss of land, buildings, parking areas and streets. In addition, the maintenance of the existing structures would be greatly reduced or eliminated. The recreational benefits would be derived from increased use of the improved bathing area. The total annual benefits were estimated to be \$16,500.

The ratio of the estimated annual benefits to the estimated annual cost was found to be 1.4, indicating economic justification for federal participation in the construction of a beach erosion control project at Provincetown Beach.

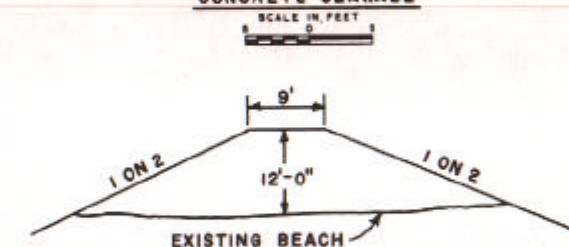
Based on the study findings, the Division Engineer recommended in the report that the United States adopt a beach erosion control project for Provincetown Beach, authorizing federal participation in an amount equal to one-third of the first cost of construction, which was estimated to be \$88,000.

The project was adopted by the River and Harbor Act of 14 July 1960 and modified by the River and Harbor Act of 1962. The 1962 Act increased the allowable federal participation to an amount equal to 70 percent of the total first cost of the project. The authorized project is shown on the project map at the end of this section.

In June 1963 Provincetown Beach was turned over to the National Park Service. Due to a lack of interest by the National Park Service in pursuing the authorized project it was placed in an inactive status on 17 September 1971 without having had any work done on the project since it was initially authorized.



### PROFILE CONCRETE SEAWALL



**TYPICAL SECTION - GROIN**



**PROVINCETOWN BEACH**  
**PROVINCETOWN, MASS.**  
(HERRING COVE BEACH)  
CAPE COD NATIONAL SEASHORE

30 SEPTEMBER 1976

IN | SHEET

SCALE IN FEET



DEPARTMENT OF THE ARMY  
NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
WALTHAM, MASS.

|||| INCOMPLETED WORK

REVERE BEACH  
REVERE, MASSACHUSETTS

A cooperative beach erosion control report for Revere Beach, Revere, Mass., entitled "Beach Erosion Control Report on a Cooperative Study of Metropolitan District Commission Beaches, Massachusetts, Part B, Revere Beach" was completed on 1 June 1949. The report was prepared by the New England Division, Corps of Engineers, Department of the Army, in cooperation with the Commonwealth of Massachusetts (acting through the Metropolitan District Commission). In the report the Division Engineer recommended that the United States adopt a project for the protection and improvement of the shore of Revere Beach Reservation between Northern Circle and a point near Shirley Avenue by authorizing participation through the contribution of federal funds in an amount equal to one-third of the first cost of the construction of the project. The project consisted of improving Revere Beach Reservation by placing 522,000 cubic yards of sandfill on the beach between Northern Circle and Shirley Avenue, a distance of about 13,700 feet, to provide a backshore elevation of 18.0 feet above mean low water, except at the northern end of the beach where local conditions require backshore elevations between 16.8 and 17.3 feet above mean low water.

This project was authorized by the River and Harbor Act of 1954. The MDC constructed part of the project during 1954 by placing about 172,000 cubic yards of sandfill dredged from an offshore borrow area and pumped onto the beach between Revere Street and Shirley Avenue. Loss and redistribution of the material occurred during the operation resulting in about 90,000 cubic yards of material remaining on the beach within the area where it was placed. No other work was done in conjunction with this previously authorized project.

A second beach erosion control study for Revere Beach, Revere, Massachusetts, was made by the New England Division, Corps of Engineers, Department of the Army, in cooperation with the Commonwealth of Massachusetts (acting through the Metropolitan District Commission), under authority of Section 2 of the River and Harbor Act approved 3 July 1930, as amended and supplemented. Formal application for the cooperative study was made on 22 August 1961, and was approved by the Chief of Engineers on 19 September 1961. The results of the study are contained in the report entitled "Beach Erosion Control Report on Cooperative Study of Revere and Nantasket Beaches, Massachusetts" dated March 1968.

The study was undertaken to review the problems at Revere and Nantasket Beaches to determine the best methods of restoring and stabilizing the beaches and protecting the backshore beach developments.

Revere Beach is located in the city of Revere, Suffolk County, Massachusetts, approximately 7 miles north of the main entrance channel to Boston Harbor and 6 miles northeast of the city of Boston. The beach extends a distance of approximately  $3\frac{1}{2}$  miles northward from Roughan's Point to the mouth of the Saugus River. At the time of the study the southern half of the beach was developed as an amusement area. The northern half of the beach was developed as a middle class residential district, with the greatest population being concentrated in the Point of Pines area. The area is shown on the project map at the end of this section.

The Revere Beach Reservation is comprised of a wide boulevard, including sidewalks, a series of seawalls, pavilions and retaining walls along the seaward edge of the boulevard. A large pleasure-park development, containing all types of rides, games, amusement devices and refreshment stands borders the southerly 6,000 feet of the reservation. Bathhouse facilities are also conveniently located at the central portion of the beach. Private residences interspersed with refreshment stands and restaurants border the balance of the reservation. The area north of the reservation, designated as Point of Pines, is a densely populated, permanent residential area bounded by a paved town road paralleling the beach. The road is partially protected by miscellaneous walls, bulkheads and riprap placements. The area south of the reservation designated as Roughan's Point is a summer and year round residential area abutted by a seawall and riprap shore protection constructed by the Massachusetts Department of Public Works.

Revere Beach is exposed to direct wave attack from the open ocean from the east around through the southeast quadrant. Some protection from storm driven wave attack from the southeast quadrant is provided by the Cherry Island breakwater. The beach is afforded protection from direct storm attack from the northeast by Big and Little Nahant. Storm waves from the northeast quadrant are able to reach the beach after being reduced by refraction and diffraction around Nahant.

The problem is generally one of gradual erosion and recession of the beach area resulting in exposure of the backshore walls, roadways and structures to wave attack and flooding. This problem is caused by the loss of beach material by alongshore and offshore transport resulting from current, tidal and wave action. The situation has been aggravated by the shore development and erection of protective structures which have eliminated sources that used to supply littoral material to it. This material formerly provided a certain amount of equilibrium under natural shore processes. During severe storms, the waves which have been observed breaking on the massive concrete walls have increased losses of beach material from the backshore by scouring at the toe of the wall and some distance seaward of it.

The initial attempt at construction of the 1954 authorized project was discontinued in 1954 due to the inability to maintain the sand at the desired location. It was also noted that the fineness of the borrow material contributed substantially to the loss of beach fill.

Revere Beach has been overtopped several times in the past during severe storms. This has caused erosion of the beach fill, deposition of shingles on portions of the beach and flooding of the backshore highway and development. To reduce tidal flooding of the commercial and residential area and protect the ocean highway from erosive forces, a variety of structures have been constructed along the backshore. These structures range from massive concrete walls in areas subjected to concentrated wave forces to concrete capped steel sheet pile bulkheads in areas fronted by a wider beach.

The study determined the most natural and economical method of correcting the problem would be restoration of the beach area by the artificial placement of sandfill, thereby, providing a beach berm commensurate with natural berm widths found to be stable within the area. This, in effect, would provide a higher and wider beach, furnishing protection to shore structures from wave damage experienced during the more frequent storms by causing waves to break seaward of the structures. At the time of the study it was felt that beach material would probably be available offshore or in portions of tidal inlets. However, past experience had shown that this material might contain a great quantity of fine materials and if it was used as beach fill, it might be easily lost. It was felt a well graded land source of material trucked to the beach would be the most practical source, considering beach stability and future maintenance requirements. However, it was indicated in the report that an offshore investigation for selected beach fill material should be conducted before or at the time of final project design. It was found that a substantial offshore movement of fine material could occur, however, it was felt that much of the material could be lost through longshore littoral transport even with a better graded beach fill than had been used earlier. Therefore, the study also evaluated using groin structures at critical locations along the beach to minimize the alongshore movement and loss of material.

Two plans of improvement and protection were developed for Revere Beach during the course of the study. The first plan involved widening about 13,000 feet of beach by placement of suitable sandfill to a general backshore elevation of 18.0 feet above mean low water, thus providing a protective and recreational beach of about 185 feet in width behind the mean high waterline.

The second plan was similiar to the first but it also contained provisions for constructing 8 strategically located rock groin structures. Four of them to be located in the concentrated damage area just north of Eliot Circle and 4 of them just south of Northern Circle. The groins varied in length between about 410 feet to 615 feet and would be spaced about 1,200 feet apart.

An economic analysis was made during the course of the study to determine if federal participation and cost sharing was justified for the considered plans of improvement. A useful life of 50 years was used in determining amortization charges and a directed annual interest rate of 3.25 percent was used to establish the federal and non-federal annual charges. The first cost of the plans were based on obtaining the sandfill from a land source. For the sandfill plan only the estimated first cost was found to be \$2,400,000. This first cost included monies for 830,000 cubic yards of sandfill, contingencies, engineering, design, supervision and administration. It did not include \$20,000 worth of preauthorization costs. The total annual charges associated with this first cost were determined to be \$147,800 including provisions for 20,000 cubic yards of annual beach nourishment.

The first cost of the second plan was estimated to be \$3,250,000 exclusive of \$20,000 preauthorization costs. This first cost included funds for 830,000 cubic yards of sandfill, 49,000 tons of stone for groin construction, contingencies, engineering, design, supervision and administration. The total annual charges associated with the plan were determined to be \$163,900 and contained provisions for 10,000 cubic yards of sandfill for beach nourishment and 500 tons of stone for groin maintenance.

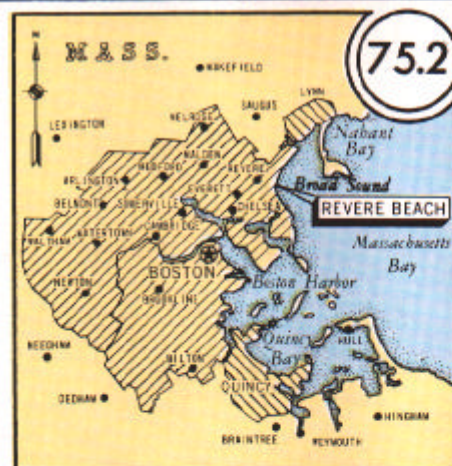
The benefits which would accrue if an improvement project was constructed would result from the promotion and encouragement of the healthful recreation of people by protection and improvement of the public beach and prevention of direct property damages. The annual benefits which would be realized if either of the plans of protection were constructed was found to be \$620,000.

The ratio of the estimated annual benefits to the estimated annual cost was found to be 4.2 for the sandfill only plan and 3.8 for the sandfill and groin structures plan. Both of these indicate there was relatively strong economic justification for federal participation in the construction of a beach erosion control project at Revere Beach. However, it was felt that the use of groin structures to reduce periodic nourishment requirements was not a very economical solution.

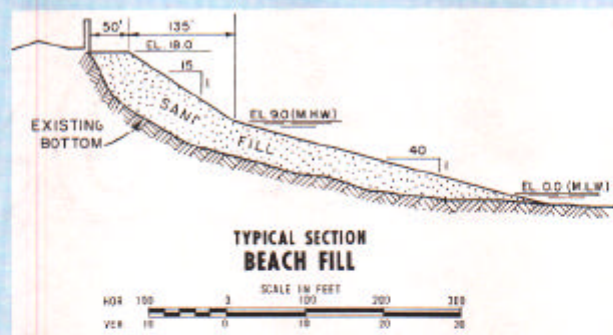
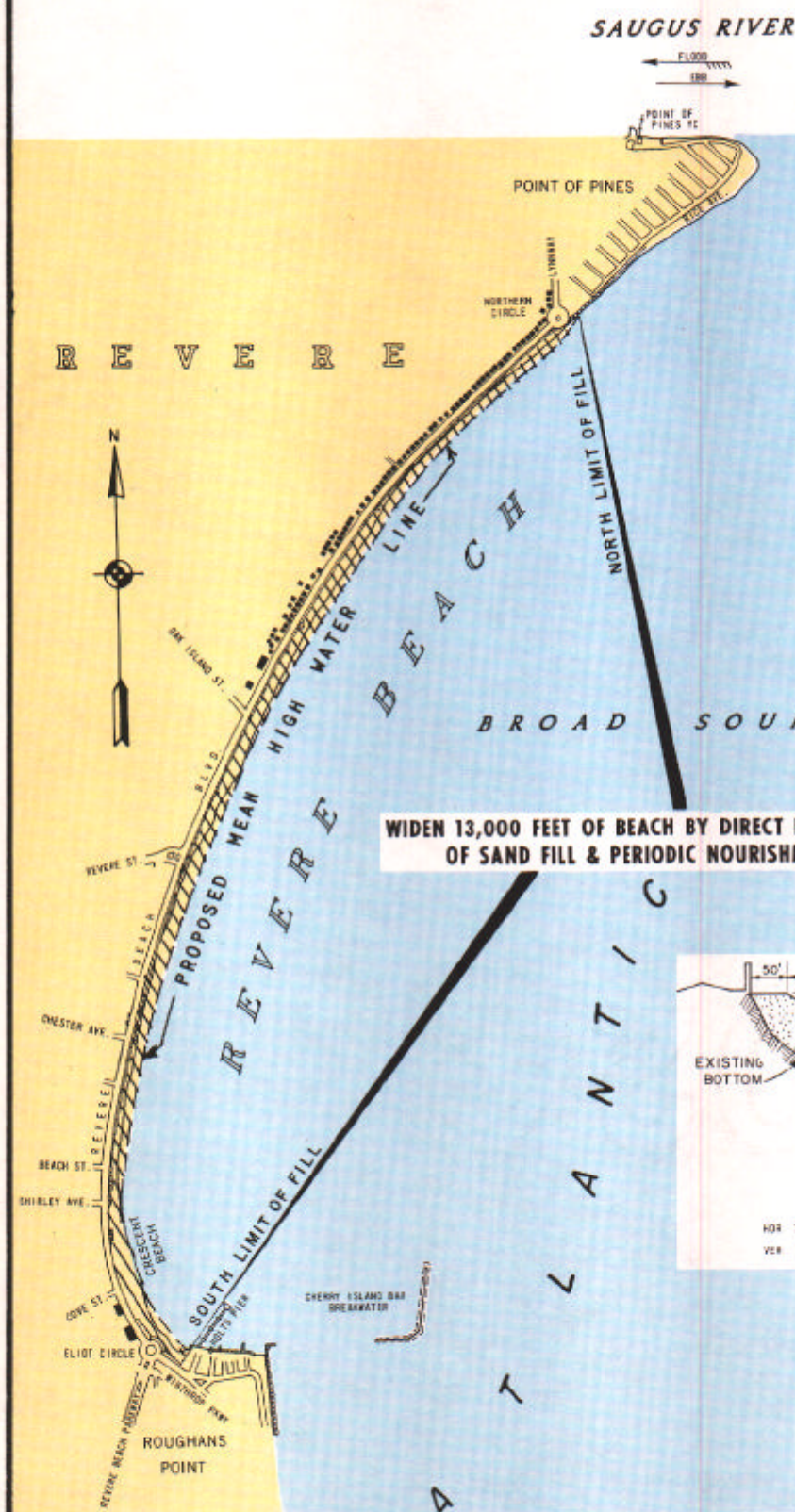
Based on the findings of the study the Division Engineer made a recommendation in the report that a beach erosion control project be adopted for Revere Beach authorizing federal participation to the extent of one-half the cost of construction of the project. The project, in lieu of the project authorized by the River and Harbor Act of 1954, provides for beach widening by direct placement of suitable sandfill along 13,000 feet of beach fronting the Metropolitan District Commission Reservation to a general backshore elevation of 18 feet above mean low water, thus furnishing a recreational and protective beach averaging 185 feet in width behind the mean high waterline. A view of what the project entails is shown by the project map sheet at the end of this section.

The existing project was authorized by House and Senate Resolutions adopted 15 December 1970 and 17 December 1970, respectively, in lieu of the project authorized by the River and Harbor Act of 1954.

To date no work has been done on the existing project authorized in 1970. However, the MDC is currently having some planning work done for the backshore area of the beach. They may also be interested in having the beach restored according to the authorized project in the future.



LOCATION MAP

SCALE IN MILES  
1 2 3 4 5

BEACH EROSION CONTROL

**REVERE BEACH  
MASS.****30 SEPTEMBER 1976**SCALE IN FEET  
0 400 800 1200 1600

INCOMPLETED WORK

DEPARTMENT OF THE ARMY  
NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
WALTHAM, MASS.

THUMPERTOWN BEACH  
EASTHAM, MASSACHUSETTS

Thumpertown Beach, Eastham, Massachusetts was one of the shoreline areas included in a study made by the New England Division of the United States Army, Corps of Engineers, in cooperation with the Commonwealth of Massachusetts, under authority of Section 2 of the River and Harbor Act approved July 3, 1930, as amended and supplemented. The results of the study are contained in the report entitled "Beach Erosion Control Report on Cooperative Study of Cape Cod Canal to Provincetown, Massachusetts" dated 2 October 1959.

Thumpertown Beach is located on the west coast of the town of Eastham on Cape Cod about equidistant from the town lines of Orleans on the south and Wellfleet on the north. It is approximately 1,500 feet in length and is owned and operated by the town. Most of the west shore of Eastham consists of narrow beaches fronting bluffs ranging up to 50 feet in height. The area is shown on the project map at the end of this section.

The main problem occurring at Thumpertown Beach at the time of the study was the gradual erosion and recession of the shoreline caused by wind, wave, tidal and current action. If it is allowed to continue it would eventually start to cut into the backshore dunes and bluffs thus endangering the backshore roadway.

The study determined that the best method to correct the problem was to restore the beach in front of the bluffs by the artificial placement of sandfill and the construction of a stone groin at the north limit of the beach to help contain the fill and to trap the littoral material moving in that direction from the south. The project map at the end of this section gives a picture of the proposed project.

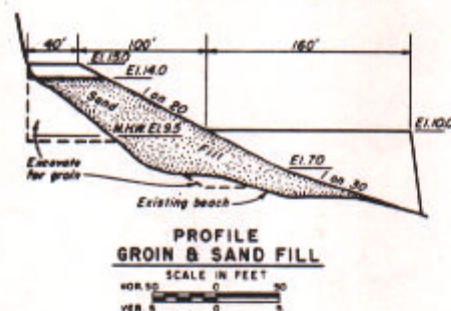
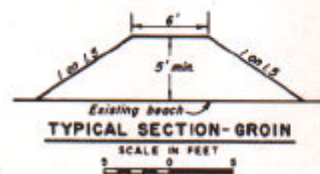
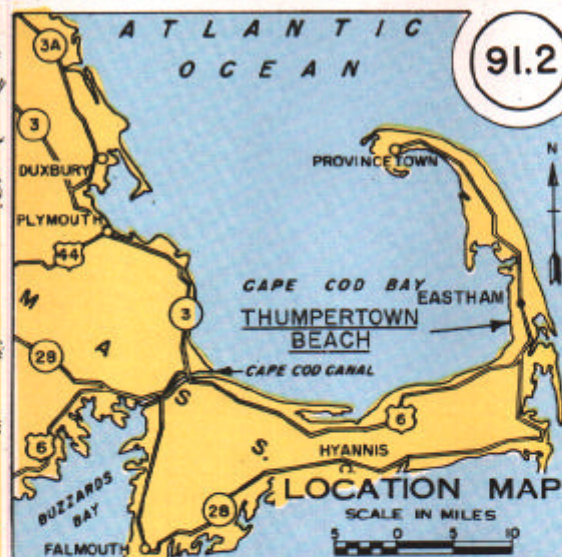
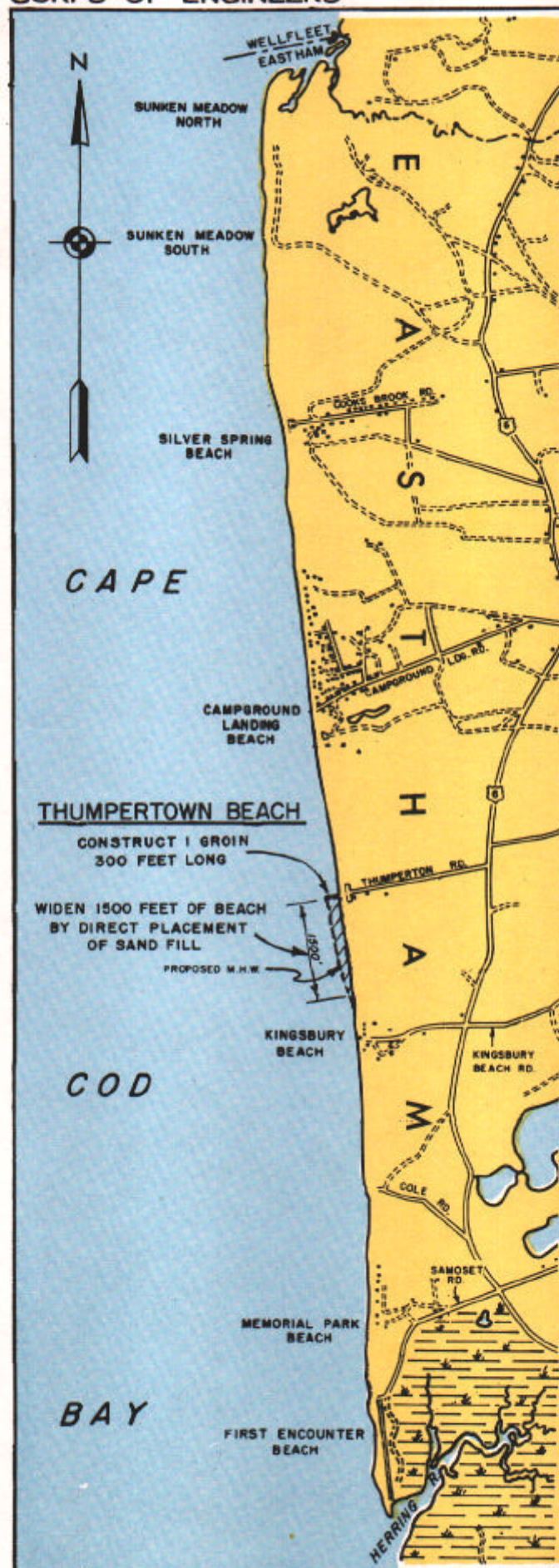
In order to determine if the considered plan of protection and improvement was economically feasible for federal participation it was necessary to make an estimate of the first cost, annual charges and benefits associated with the plan. The total first cost of the project was estimated to be \$51,000 base on 1959 prices. This cost included monies for 50,000 cubic yards of sandfill, 1,400 tons of stone for groin construction, contingencies, engineering, design, supervision and administration. The annual charges associated with the plan were computed to be \$2,900 based on a directed interest rate of 2.5 percent for the federal investment, 3 percent for the non federal investment and a project life of 50 years.

The types of benefits that could be attributed to the project, if it was constructed, included prevention of loss of land, prevention of loss of the parking area, reduction in maintenance of facilities and increased recreational use of the beach. The total annual benefits were estimated to be \$9,750.

The ratio of the estimated annual benefits to the estimated annual cost was found to be 3.4 indicating relatively strong economic justification for federal participation in the construction of a beach erosion control project at Thumpertown Beach.

In the report the Division Engineer recommended that the United States adopt a beach erosion control project for Thumpertown Beach authorizing federal participation in an amount equal to one-third of the first cost of construction which was estimated to be \$17,000.

The project was adopted by the River and Harbor Act of 15 July 1960 and modified by the River and Harbor Act of 1962. The 1962 Act provided for increased federal participation in the amount of one-half the first cost of constructing the project. No work has been done on the authorized federal project to date.

 INCOMPLETED WORK

THUMPERTOWN BEACH  
EASTHAM, MASS.

30 SEPTEMBER 1976

IN | SHEET      SCALE IN FEET

1000      0      1000      2000      3000

DEPARTMENT OF THE ARMY  
NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
WALTHAM, MASS.

TOWN NECK BEACH  
SANDWICH, MASSACHUSETTS

A beach erosion control study of the north shore of Cape Cod from the Cape Cod Canal in Sandwich to Provincetown, Massachusetts, was made by the Corps of Engineers, United States Army, in cooperation with the Commonwealth of Massachusetts under authority of Section 2 of the River and Harbor Act approved 3 July 1930, as amended and supplemented. The formal application for the study dated 10 June 1957 was approved by the Chief of Engineers on 19 June 1957. One of the shore areas included in the study was that of Town Neck Beach, Sandwich, Massachusetts. The results of that study are contained in the report entitled "Beach Erosion Control Report on Cooperative Study of Cape Cod Canal to Provincetown, Massachusetts" dated 2 October 1959.

Town Neck Beach is a publicly owned and operated beach by the town of Sandwich, located on the northern coast of Cape Cod just east of the Cape Cod Canal. The beach is shown on the project map at the end of this section.

At the time of the study approximately 6,500 feet of the beach was developed for recreational use. Of this total nearly the entire shoreline was experiencing an erosion problem.

The problem was basically found to be one of erosion and recession of the shoreline of from 1 to 4 feet per year due to wind, wave, tidal and current action in the area. The problem was also found to be aggravated by the construction of protective structures along the adjoining shoreline which had reduced the supply of littoral drift that formerly helped to nourish the shoreline.

At the time of the study the development behind the beach consisted of a paved access road, 2 paved parking areas and a small bathhouse. Protective structures included a stone jetty 600 feet long at the west end of the beach at the entrance to the Cape Cod Canal, a stone and concrete caisson jetty 350 feet long at the east end at the entrance to Sandwich Harbor and six stone groins 150 to 200 feet in length spaced between these jetties.

The study determined the most feasible plan of protection and improvement for beach would consist of raising the inshore end of the north Cape Cod Canal jetty by adding about 1,400 tons of stone and widening the entire 6,500 feet of beach to a 125 foot width by direct placement of about 165,000 cubic yards of suitable sandfill. Due to the conditions in the area it was determined that the beach would require replenishment at suitable intervals, to be determined

by experience, and as a first estimate a figure of 4,000 cubic yards per year was felt to be reasonable.

Due to the fact that the north jetty at the entrance to the Cape Cod Canal was an existing federal structure and raising the structure would reduce the flow of sand over the jetty into the canal, thus aiding navigation, it was determined that the cost of modifying the structure would be totally born by the United States.

An economic analysis was conducted during the course of the study to determine the first cost, annual charges and benefits associated with the plan of improvement to determine if there was enough economic justification for federal participation in the construction of the project. The total first cost of the project was estimated to be \$171,000 based on 1959 price levels. This estimated first cost included monies for 165,000 cubic yards of sandfill, contingencies, engineering, design, supervision and administration. In addition the first cost of raising the jetty, which was estimated to be \$10,000 was deemed to be entirely a federal cost which eliminated the need for local cost sharing. The annual charges associated with the first cost of construction of the project were based on a directed interest rate of 2.5% for the federal investment, 3% for the non-federal investment and a project life of 50 years and was determined to be \$10,000.

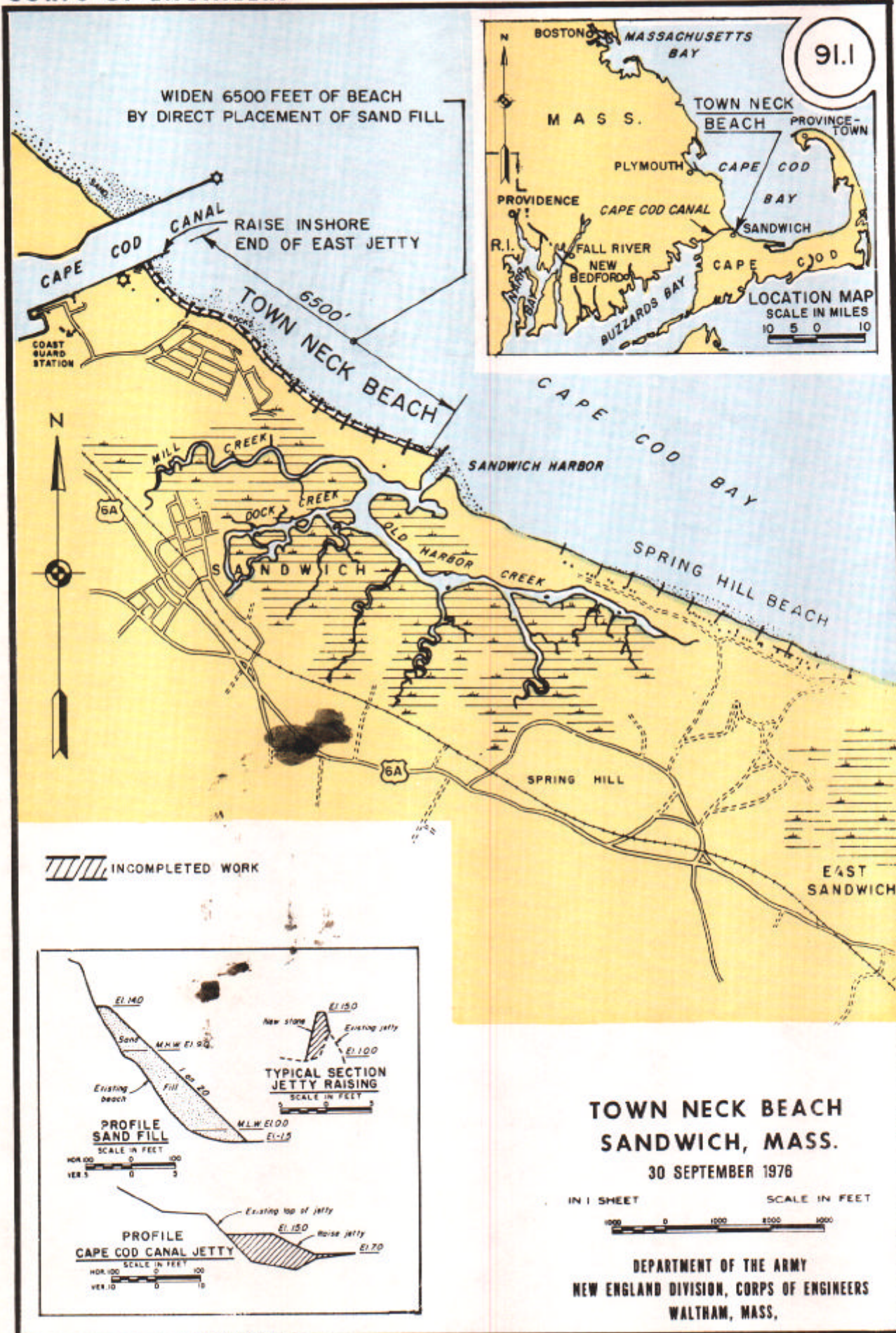
The benefits which would be derived if the project was constructed are elimination of direct damages and an increase in the recreational use of the area. The direct damages which would be eliminated include loss of land, buildings, parking areas and streets. In addition, the maintenance of the existing structures would be greatly reduced or eliminated. The recreational benefits would be derived from increased use of the improved bathing area. The total annual benefits were estimated to be \$13,600.

The ratio of the estimated annual benefits to the estimated annual cost was found to be 1.4 indicating economic justification for federal participation in the construction of a beach erosion control project at Town Neck Beach.

Based on the study findings the Division Engineer recommended in the report that the United States adopt a beach erosion control project for Town Neck Beach authorizing federal participation in an amount equal to one-third of the first cost of construction which was estimated to be \$63,000.

The project was adopted by the River and Harbor Act of 14 July 1960 and modified by the River and Harbor Act of 1962. The 1962 Act increased federal funding to 50% of first cost of the beach construction

and nourishment costs of the beach for 10 years after completion of the project. The authorized project is shown on the project map at the end of this section. To date no work has been done on the authorized project.



## *PART IV*

# *DISCUSSION AND CONCLUSIONS*

### *Discussion*

The 1,200 miles of shoreline in Massachusetts are vulnerable to attack by two types of severe tropical coastal storms. Of the two, hurricanes are the most destructive but fortunately occur with less frequency than the other type of tropical storm commonly referred to as a "Northeaster".

The history of hurricanes moving through New England has shown that generally in Massachusetts only the south shore of Cape Cod, the outer islands and the Buzzards Bay area to the Rhode Island State line bear the brunt of the damages associated with hurricane generated tidal surges which move up the Atlantic coast. In particular, the Buzzards Bay area, from the Rhode Island State line to Falmouth, receives about 90 percent of all hurricane tidal flood damages. Within this area the greatest concentrations of damages have occurred in the New Bedford - Fairhaven and the Wareham - Marion localities. Four severe hurricanes in Massachusetts in the past 40 years have caused serious problems of tidal flooding and beach erosion. The most devastating of these was that of 21 September 1938 which caused tidal flooding of over 14 feet above mean sea level, a loss of 187 lives and damages in the millions of dollars. Other hurricanes in the period were those of 14-15 September 1944, 31 August 1954 and 12-13 September 1960.

In view of the severe damages from hurricanes sustained, not only in Massachusetts, but also along the eastern and southern coastal areas of the United States, the 84th Congress, 1st Session, on 15 June 1955, adopted Public Law No. 71 which authorized the Corps of Engineers to undertake a study of means to prevent the loss of human life and damages to property from hurricane tidal flooding.

As a result of this legislation a hurricane protection project was authorized and constructed for the New Bedford - Fairhaven area. A hurricane protection project was also authorized for the Wareham - Marion area by the Flood Control Act of 1962. However, due to a lack of local cooperation it was never constructed and has since been deauthorized in August 1977. The New Bedford Hurricane Barrier constructed in 1966, has proved to be very effective in reducing flood damages during storm conditions. From 1966 through October of 1977 the barrier has been operated 76 times. It has been estimated that \$2,360,000 worth of flood damages in the area have been prevented by the barrier during the eleven year period.

Although hurricane activity causes damages along the south shore of Cape Cod, the outer islands and Buzzards Bay, storms with winds from the north and east strike the vulnerable north shore of Massachusetts and the north side of the Cape. Major problems are caused by these storms from the northeast, commonly referred to as "Northeasters". Northeasters have a higher frequency of occurrence than hurricanes and may occur during any time of the year although they are more numerous in the winter. Some of the storms may pass rapidly; however, others have been known to stall for several days over an area while flooding recurs at each high tide and wave damage and erosion not only continue unabated but increase with each successive tide as the shore defenses are weakened. From past records it has been noted that the principal damage centers north of Cape Cod include Hull, Quincy, Scituate and the Boston Complex, particularly the Revere - Saugus River area.

Several of the more recent northeast storms such as those of 19-20 February 1972, 20 January 1961 and 29 December 1959 have caused millions of dollars in damages, loss of lives and an enormous amount of hardship for countless people.

As a result of these severe storms and those of lesser magnitude, a substantial amount of erosion has been experienced at locations along the Massachusetts coastline. These storms and the associated damages have caused state and local officials to request the Corps of Engineers to conduct beach erosion control studies along publicly owned shorefronts with a view to developing plans of protection and improvement for the areas.

These studies led to seven federal beach erosion control projects that have been completely or partially constructed along the Massachusetts coastline. In addition to providing protection to property and structures, the projects also provide for the healthful recreation of the general populace through the creation of a barrier beach by direct placement of sandfill. The projects which have received periodic maintenance as required have been found to be effectively serving their intended purpose.

In addition to the seven constructed beach erosion control projects, another eight projects have been authorized for construction but for various reasons no work has been accomplished on them to date.

## *Conclusions*

It has been vividly pointed out by several storm events in the past that development along the Massachusetts coastline is susceptible to tidal flooding and wave attack during hurricanes, northeasters and other lesser magnitude storm events. These storms have caused extensive damage to, or loss of, private and public structures, facilities, land and, in extreme cases, loss of life. Areas which have been repeatedly hard hit include the Buzzards Bay area, from the Rhode Island state line to Falmouth, Hull, Quincy, Scituate and the Boston Complex, particularly the Revere - Saugus River area.

In an effort to guard against the destruction and havoc caused by these storms various federal, state, county, local and private individuals and agencies have built a number of protective works at scattered locations along the coastline. In cases where these protective works have been properly designed constructed and adequately maintained, they have been found to be effective in reducing tidal flood damage and erosion for all but the most severe storm events. In other instances where they have not been properly designed or constructed and have not received required maintenance they have been of little value in protecting against tidal flooding and wave attack.

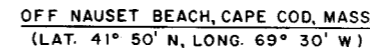
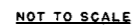
At the federal level the Corps has been very active in conducting hurricane protection and beach erosion control studies for various locations along the Massachusetts coastline in cooperation with state and local agencies. These studies have resulted in the authorization and construction of several projects which have been discussed earlier in this report.

At the state level the Division of Waterways, formerly under the Department of Public Works and now under the Department of Environmental Quality Engineering, has been very active in conducting studies on their own and in conjunction with federal, state or local agencies in the interest of shore protection and navigation all along the Massachusetts coastline. As a result, they have constructed and maintained a number of shore protection and navigation projects throughout Massachusetts. Information regarding these projects is available at the Division of Waterways office.

Based on past experience it appears that unless some remedial action is taken future storms will continue to cause untold damages and even loss of life along the Massachusetts coastline especially in areas that have experienced severe damages in the past. The situation is being aggravated by the increasing demand for both residential and commercial development all along the coast.

In order to lessen the impact of the destruction caused by tidal flooding and wave action during future storms it is going to be necessary to employ both structural and nonstructural methods and measures. Some hard decisions are going to have to be made at all levels of government as to how to control and protect existing and future coastal development. A thorough evaluation of the economic and environmental conditions in an area will need to be made in order to arrive at an acceptable decision. A number of concessions, compromises and mitigative action may have to be taken during the decision making process to ensure its success.

At the present time it is imperative that the intensely developed areas which have been heavily damaged in the past and for which no protection has been afforded or proposed be looked at first. Eventually evaluation in detail of the whole coastline will be necessary. The recently approved Coastal Zone Management plan for Massachusetts should prove invaluable in helping to carry out this process. As in the past, the Corps is now willing and anxious to provide assistance and input to this process whenever requested by state and local officials.



**LOGAN AIRPORT, BOSTON, MASS.**  
**OCTOBER 1949-SEPTEMBER 1959**  
**10 YEAR RECORD**

\* DURATION FOR EACH RANGE OF WIND SPEEDS IS MEASURED OUTWARD FROM TOP OF UNDERLYING BAR GRAPH.

NOTE:

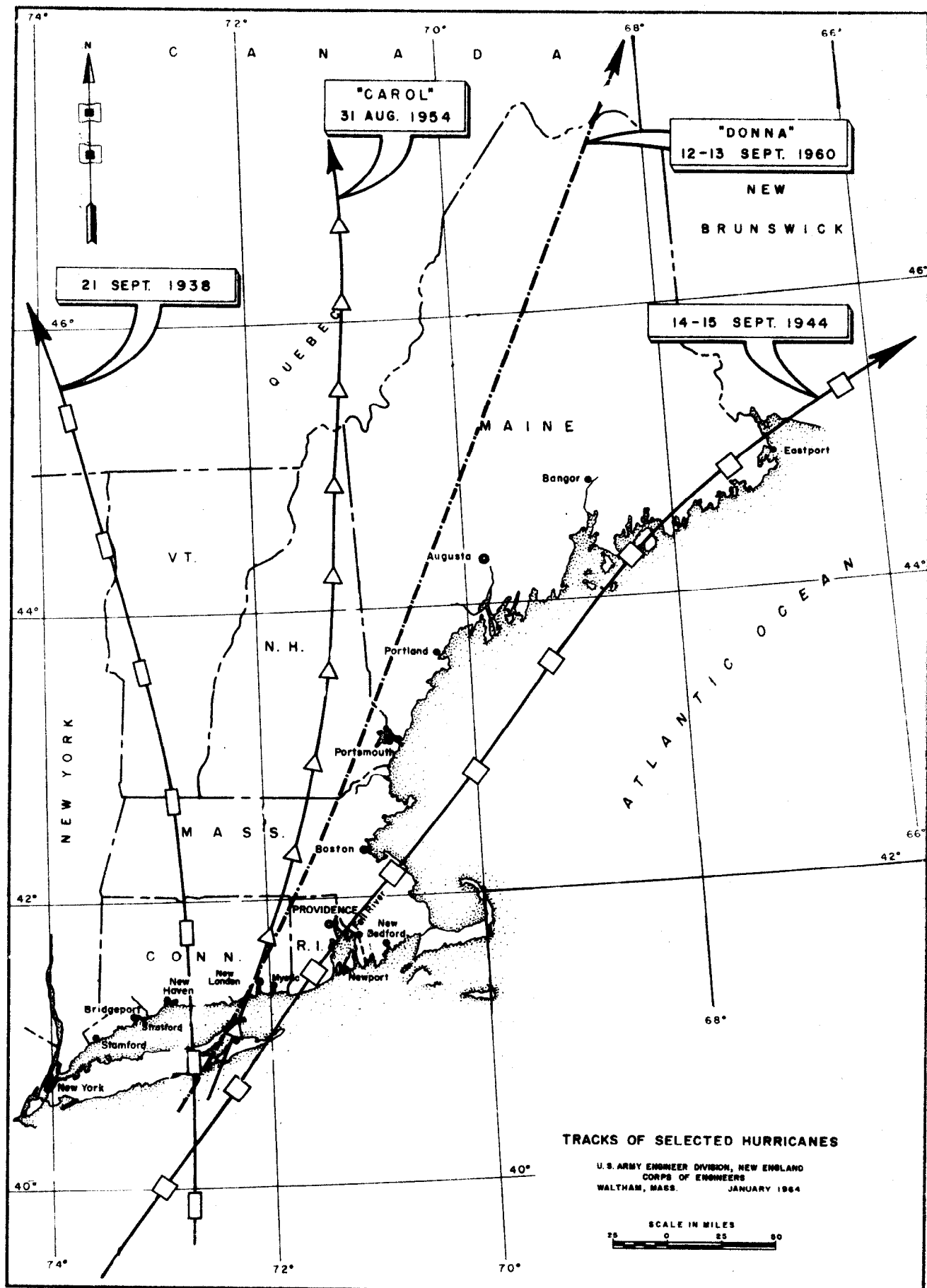
PERCENT DURATION PER DEGREE IS THE AVERAGE PERCENT DURATION OBSERVED FOR EACH 16 POINTS OF THE COMPASS DIVIDED BY 22 1/2 DEGREES.

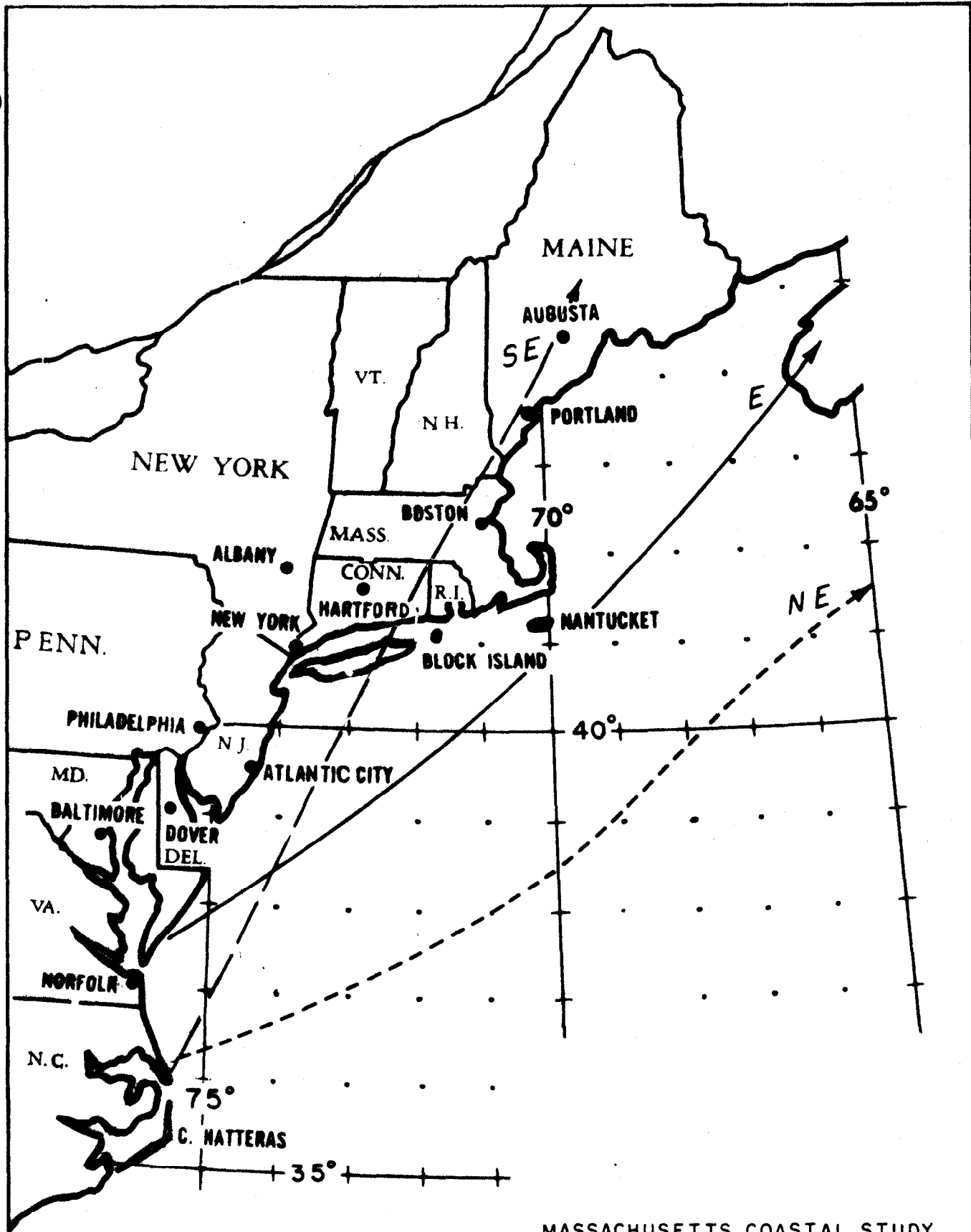
**LEGEND**

— — — COUNTY LINE  
— — — STATE LINE  
- - - CITY AND TOWN BOUNDARY  
⊙ NATIONAL OCEAN SURVEY TIDE GAGING STATION  
□ EXISTING FEDERAL BEACH EROSION CONTROL PROJECT  
△ PARTIALLY COMPLETED FEDERAL BEACH EROSION CONTROL PROJECT  
+ AUTHORIZED FEDERAL BEACH EROSION CONTROL PROJECT NO WORK DONE ON PROJECT TO DATE  
○ EXISTING FEDERAL HURRICANE PROTECTION PROJECT.

MASSACHUSETTS COASTAL STUDY  
LOCATION MAP

NEW ENGLAND DIVISION-CORPS OF ENGINEERS  
JULY 1978

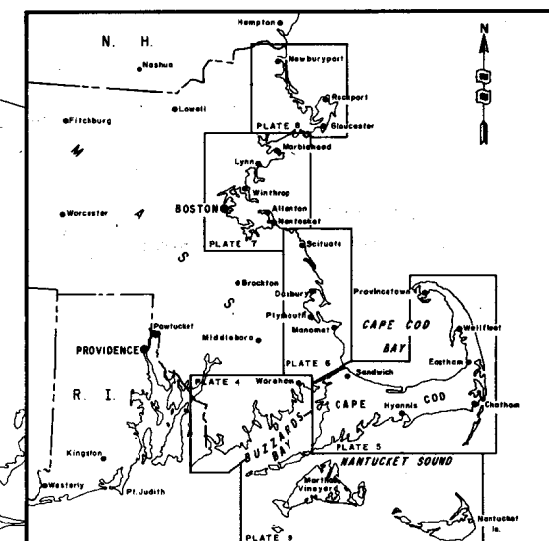
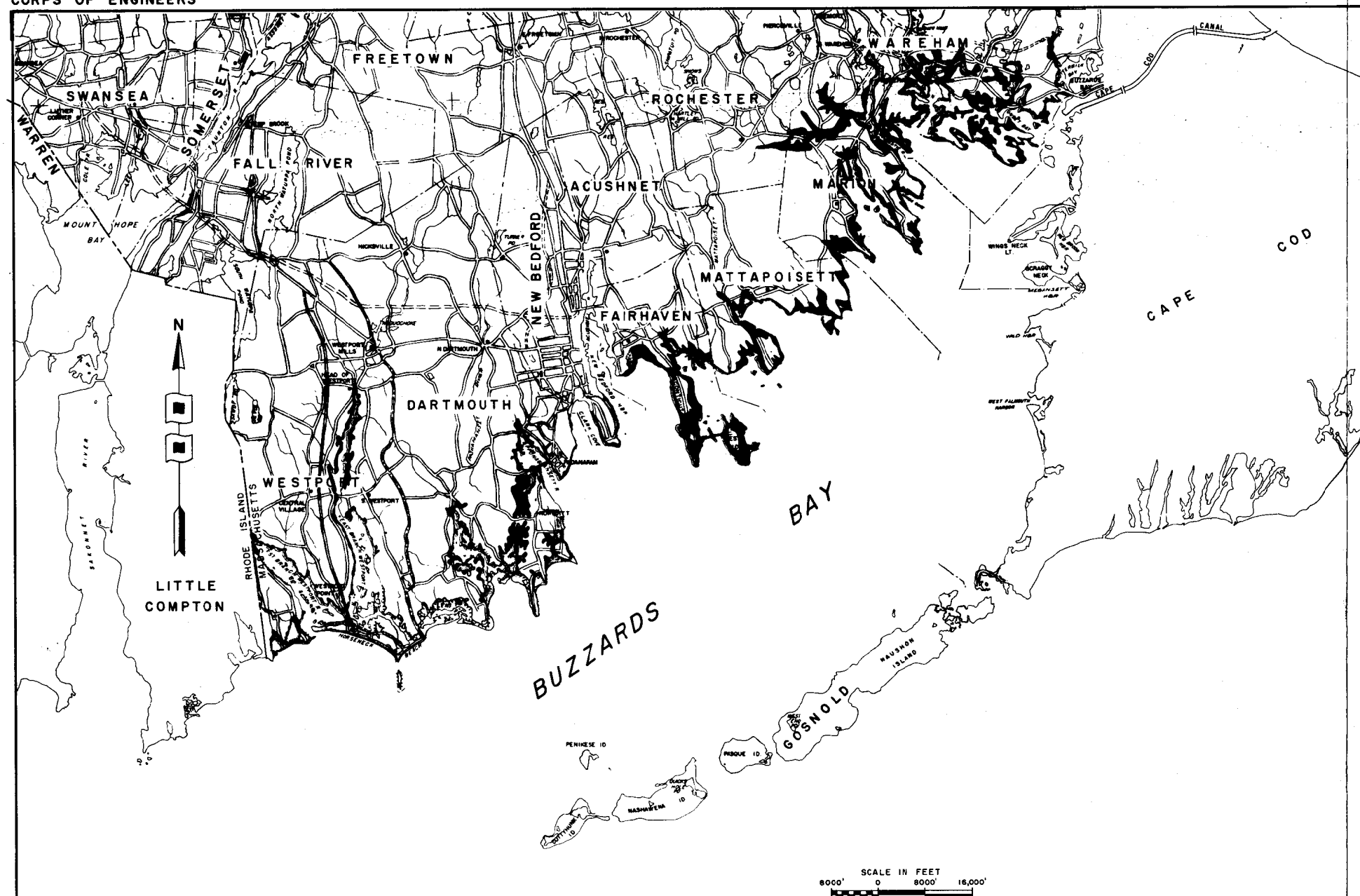




SOURCE: UNITED STATES WEATHER  
BUREAU, MEMORANDUM  
HUR 8-5, 1963

MASSACHUSETTS COASTAL STUDY  
MEAN TRACKS OF SURGE-  
PRODUCING NORTHEASTERS

NEW ENGLAND DIVISION-CORPS OF ENGINEERS  
JULY 1978



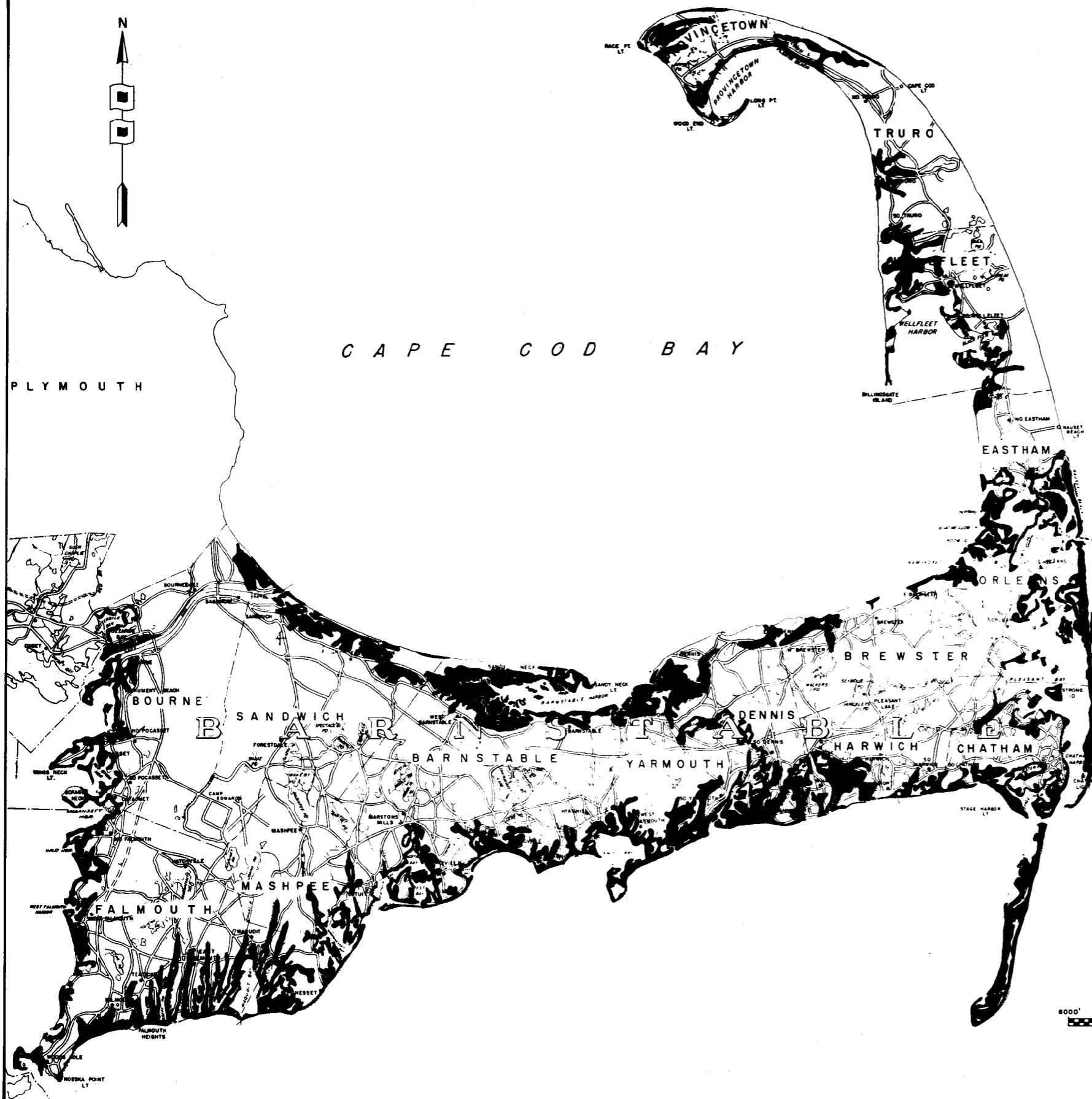
LOCATION MAP

SCALE IN MILES  
0 10 20 30 40**LEGEND:**AREAS SUBJECT TO  
TIDAL FLOODING.**NOTE:**

THIS PLATE AND PLATES 5, 6, 7, 8 & 9  
WERE TAKEN FROM THE HURRICANE  
SURVEY INTERIM REPORT ENTITLED  
"MASSACHUSETTS COASTAL AND TIDAL  
AREAS", DATED 5 AUGUST 1964, PRE-  
PARED BY THE NEW ENGLAND DIVISION  
OF THE U. S. ARMY, CORPS OF ENGINEERS.

**MASSACHUSETTS  
COASTAL STUDY  
BUZZARDS BAY**

NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
JULY 1978

**LEGEND:**

AREAS SUBJECT TO  
TIDAL FLOODING.

**MASSACHUSETTS  
COASTAL STUDY  
CAPE COD**

NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
JULY 1978

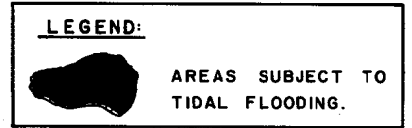
**LEGEND:**

AREAS SUBJECT TO  
TIDAL FLOODING.

**MASSACHUSETTS  
COASTAL STUDY  
SOUTH SHORE**

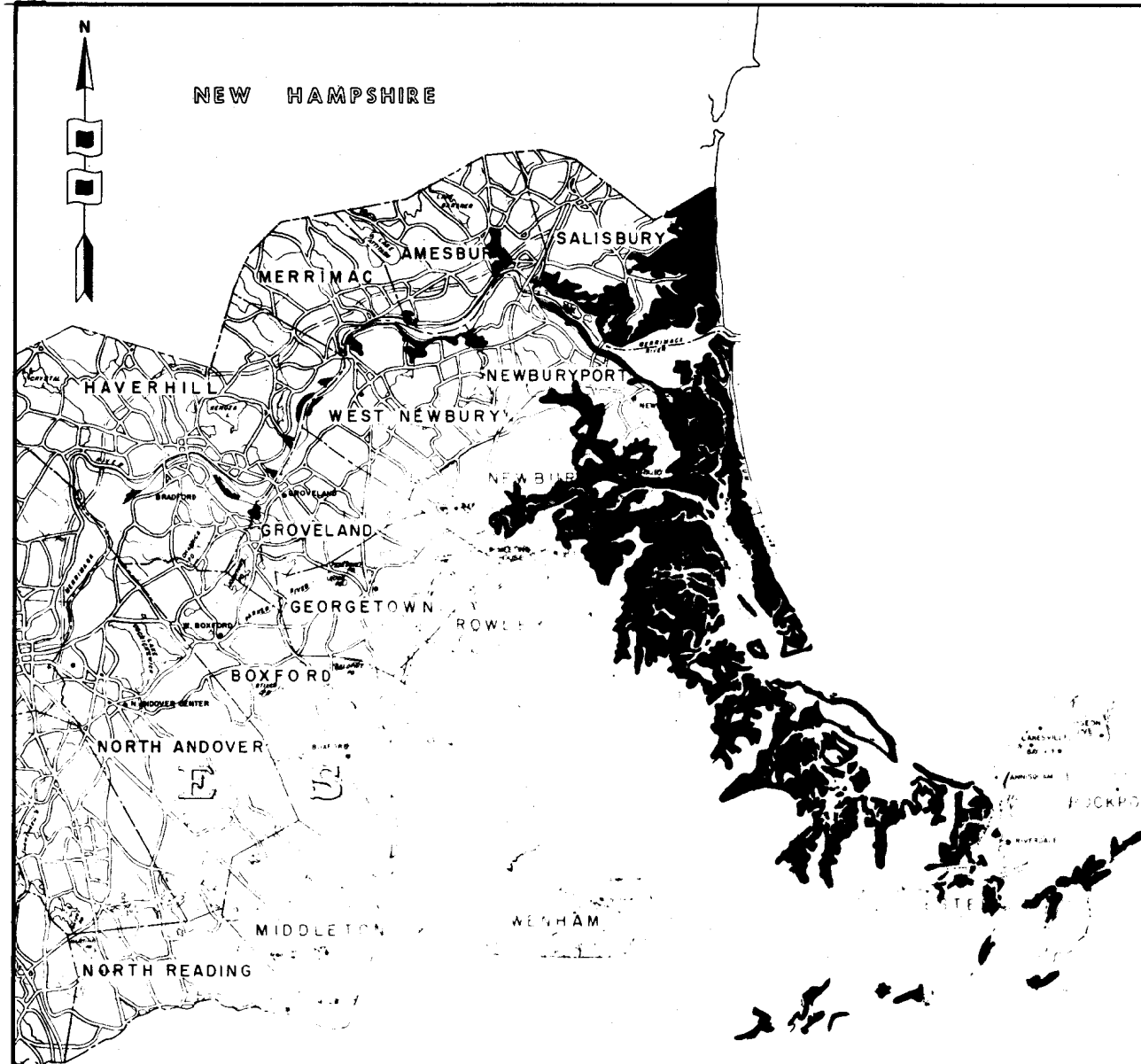
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NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
JULY 1978




MASSACHUSETTS  
COASTAL STUDY  
BOSTON

NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
JULY 1978

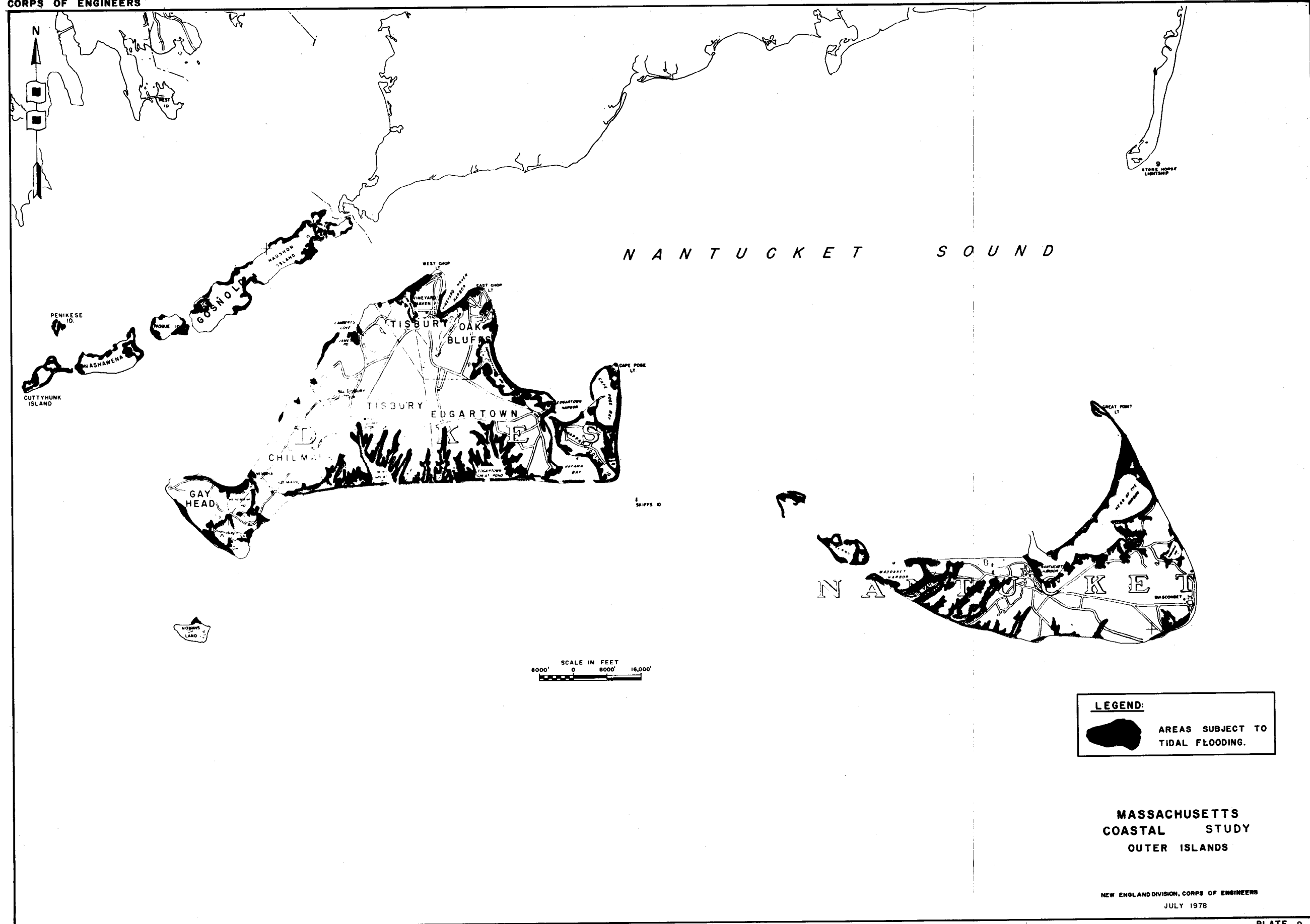


**LEGEND:**

 AREAS SUBJECT TO TIDAL FLOODING.

**MASSACHUSETTS  
COASTAL STUDY  
NORTH SHORE**

NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
JULY 1978



MASSACHUSETTS  
COASTAL STUDY  
OUTER ISLANDS

NEW ENGLAND DIVISION, CORPS OF ENGINEERS  
JULY 1978

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**COASTAL STUDY**

**PRIOR STUDIES  
AND REPORTS**

**PREPARED BY THE  
NEW ENGLAND DIVISION  
CORPS OF ENGINEERS  
DEPARTMENT OF THE ARMY**

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# PRIOR STUDIES AND REPORTS

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Hurricane and Northeaster Reports	3

# APPENDIX A

## BIBLIOGRAPHY OF BEACH EROSION CONTROL AND HURRICANE REPORTS

Prepared By

The Corps of Engineers for the Massachusetts Coastline

### Beach Erosion Reports

<u>Study Area</u>	<u>Report Date</u>	<u>Report Recommendation</u>	<u>House or Senate Document No.</u>
Cape Cod, MA Chatham to Pt. Gammon	26 August 1941	Unfavorable	Unpublished
Winthrop Beach	12 September 1947	Favorable	H.D. #764 80th Congress 2nd Session
Revere Beach	1 June 1949	Favorable	H.D. #146 82nd Congress 1st Session
Lynn-Nahant Beach	1 June 1949	Favorable	H.D. #134 82nd Congress 1st Session
Nantasket Beach	1 June 1949	Unfavorable	Unpublished
Quincy Shore Beach	1 June 1949	Favorable	H.D. #145 82nd Congress 1st Session
Chatham	27 July 1956	Unfavorable	H.D. #167 85th Congress 1st Session
Pemberton Point to Cape Cod Canal	31 July 1957	Favorable	H.D. #272 86th Congress 1st Session
Wessagussett Beach Weymouth	17 April 1959	Favorable	H.D. #334 86th Congress 2nd Session

Appendix A

<u>Study Area</u>	<u>Report Date</u>	<u>Report Recommendation</u>	<u>House or Senate Document No.</u>
Cape Cod Canal to Race Point, Provincetown	2 October 1959	Favorable	H.D. #404 86th Congress 2nd Session
Salisbury Beach	15 September 1961	Unfavorable	H.D. #517 87th Congress 2nd Session
Rockport	29 September 1961	Unfavorable	H.D. #515 87th Congress 2nd Session
Clark Point New Bedford	11 May 1961	Favorable	H.D. #584 87th Congress 2nd Session
Falmouth	28 December 1962	Unfavorable	H.D. #326 2nd Session
Oak Bluffs Town Beach	12 August 1965	Favorable	- -
Martha's Vineyard	12 August 1965	Unfavorable	- -
Revere and Nantasket Beaches	28 March 1968	Favorable	H.D. #211 91st Congress 2nd Session
Gay Head Cliffs Martha's Vineyard	September 1973	Unfavorable	- -
Plum Island Beach	December 1976	Unfavorable	- -
South Shore of Barnstable	February 1977	Unfavorable	- -

# APPENDIX A

## HURRICANE AND NORTHEASTER REPORTS

<u>Study Area</u>	<u>Report Date</u>	<u>Report Recommendation</u>	<u>House or Senate Document No.</u>
New Bedford Fairhaven Interim Report	8 February 1957	Favorable	H.D. #195 87th Congress 1st Session
Narragansett Bay Area R.I. & Mass.	15 February 1957	Favorable	H.D. #230 85th Congress 1st Session
Resume Report on the Storm of 29 Dec. 1959 for the Coastal Region of New England	19 February 1960	Not Applicable	- -
Postflood Report Hurricane "Donna" 12-13 September 1960 for the Coastal Region of New England	December 1960	Not Applicable	- -
Wareham and Marion Interim Report	25 October 1961	Favorable	H.D. #548 87th Congress 2nd Session
Hurricane Survey Interim Report, Mass. Coastal and Tidal Area	5 August 1964	Unfavorable	H.D. #293 89th Congress 1st Session
Hurricane Survey Narragansett Bay Area R.I. and Mass.	11 January 1965	Favorable	- -

**MASSACHUSETTS**

**COASTAL STUDY**

# **GLOSSARY OF TERMS**

**PREPARED BY THE  
NEW ENGLAND DIVISION  
CORPS OF ENGINEERS  
DEPARTMENT OF THE ARMY**

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# GLOSSARY OF TERMS

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Terms

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Appendix B

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## APPENDIX B

This section of Appendix B will deal with an explanation of technical terms, to better assist the reader in understanding the words, phrases and verbage associated with beach erosion.

**ACCRETION** - May be either NATURAL or ARTIFICIAL. Natural accretion is the buildup of land solely by the action of the forces of nature on a BEACH by deposition of waterborne or airborne material. Artificial accretion is a similar buildup of land by reason of an act of man, such as the accretion formed by a groin, breakwater, or beachfill deposited by mechanical means.

**ALONGHSORE** - Parallel to and near the shoreline; same as LONGSHORE.

**BACKSHORE** - The zone of the shore or beach lying between the foreshore and the coastline and acted upon by waves only during severe storms, especially when combined with exceptionally high water. Also **BACKBEACH**. It comprises the **BERM** or **BERMS**.

**BAR** - A submerged or emerged embankment of sand, gravel, or other unconsolidated material built on the sea floor in shallow water by waves and currents.

**BARRIER BEACH** - A bar essentially parallel to the shore, the crest of which is above normal high water level. Also called **OFFSHORE BARRIER** and **BARRIER ISLAND**.

**BAY** - A recess in the shore or an inlet of a sea between two capes or headlands, not as large as a gulf but larger than a cove.

**BEACH** - The zone of unconsolidated material that extends landward from the low water line to the place where there is a marked change in material or physiographic form, or the line of permanent vegetation (usually the effective limit of storm waves). The seaward limit of a beach - unless otherwise specified - is the mean low water line. A beach includes **FORESHORE** and **BACKSHORE**.

**BEACH BERM** - A nearly horizontal part of the beach or backshore formed by the deposit of material by wave action. Some beaches have no berms, others have one or several.

**BEACH EROSION** - The carrying away of beach materials by wave action, tidal currents, littoral currents, or wind.

**BEACH FACE** - The section of the beach normally exposed to the action of the wave uprush. The **FORESHORE** of a BEACH.

BEACH WIDTH - The horizontal dimension of the beach measured normal to the shoreline.

BLUFF - A high steep bank or cliff.

BOTTOM - The ground or bed under any body of water; the bottom of the sea.

BOULDER - A rounded rock more than 10 inches in diameter: larger than a cobblestone.

BREAKER - A wave breaking on a shore, over a reef, etc. Breakers may be classified into four types:

SPILLING - bubbles and turbulent water spill down front face of wave. The upper 25 percent of the front face may become vertical before breaking. Breaking generally occurs over quite a distance.

PLUNGING - crest curls over air pocket; breaking is usually with a crash. Smooth splash-up usually follows.

COLLAPSING - breaking occurs over lower half of wave. Minimal air pocket and usually no splash-up. Bubbles and foam present.

SURGING - wave peaks up, but bottom rushes forward from under wave and wave slides up beach face with little or no bubble production. Water surface remains almost plane except where ripples may be produced on the beachface during runback.

BREAKWATER - A structure protecting a shore area, harbor, anchorage, or basin from waves.

BULKHEAD - A structure or partition to retain or prevent sliding of the land. A secondary purpose is to protect the upland against damage from wave action.

CENTRAL PRESSURE INDEX (CPI) - The estimated minimum barometric pressure in the "eye" (approximate center) of a particular hurricane. The CPI is considered the most stable index to intensity of hurricane wind wind velocities in the periphery of the storm; the highest wind speeds are associated with storms having the lowest CPI.

CLIFF - A high, steep face of rock; a precipice.

COAST - A strip of land of indefinite width (may be several miles) that extends from the shoreline inland to the first major change in terrain features.

COASTAL AREA - The land and sea area bordering the shoreline.

COASTAL PLAIN - The plain composed of horizontal or gently sloping strata of clastic materials fronting the coast, and generally representing a strip of sea bottom that has emerged from the sea in recent geologic time.

COASTLINE - (1) Technically, the line that forms the boundary between the COAST and the SHORE. (2) Commonly, the line that forms the boundary between the land and the water.

COVE - A small, sheltered recess in a coast, often inside a larger embayment.

CURRENT - A flow of water.

CURRENT, COASTAL - One of the offshore currents flowing generally parallel to the shoreline in the deeper water beyond and near the surf zone. They are not related genetically to waves and resulting surf, but may be related to tides, winds, or distribution of mass.

CURRENT, LITTORAL - Any current in the littoral zone caused primarily by wave action, e.g., longshore current, rip current.

CURRENT, LONGSHORE - The littoral current in the breaker zone moving essentially parallel to the shore, usually generated by waves breaking at an angle to the shoreline.

DUNES - Ridges or mounds of loose, wind-blown material, usually sand.

DURATION - In wave forecasting, the length of time the wind blows in nearly the same direction over the FETCH (generating area).

EROSION - The wearing away of land by the action of natural forces. On a beach, the carrying away of beach material by wave action, tidal currents, littoral currents, or by deflation.

ESTUARY - (1) The part of a river that is affected by tides. (2) The region near a river mouth in which the fresh water of the river mixes with the salt water of the sea.

EYE - In meteorology, usually the "eye of the storm" (hurricane); the roughly circular area of comparatively light winds and fair weather found at the center of a severe tropical cyclone.

FETCH - The area in which SEAS are generated by a wind having a rather constant direction and speed. Sometimes used synonymously with FETCH LENGTH.

FOREDUNE - The front dune immediately behind the backshore.

FORESHORE - The part of the shore lying between the crest of the seaward berm (or upper limit of wave wash at high tide) and the ordinary low water mark, that is ordinarily traversed by the uprush and backrush of the waves as the tides rise and fall.

GROIN (British, Groyne) - A shore protection structure built (usually perpendicular to the shoreline) to trap littoral drift or retard erosion of the shore.

GROIN SYSTEM - A series of groins acting together to protect a section of beach. Commonly called a groin field.

HARBOR (British, HARBOUR) - Any protected water area affording a place of safety for vessels.

HEADLAND (HEAD) - A high steep-faced promontory extending into the sea.

HIGH TIDE, HIGH WATER (HW) - The maximum elevation reached by each rising tide.

HIGH WATER LINE - In strictness, the intersection of the plane of mean high water with the shore. The shoreline as delineated on the nautical charts of the U.S. Coast and Geodetic Survey is an approximation of the high water line. For specific occurrence, the highest elevation on the shore reached during a storm or rising tide, including meteorological effects.

HURRICANE - An intense tropical cyclone in which winds tend to spiral inward toward a core of low pressure, with maximum surface wind velocities that equal or exceed 75 mph (65 knots) for several minutes or longer at some points. Tropical storm is the term applied if maximum winds are less than 75 mph.

HURRICAN PATH OR TRACK - Line of movement (propagation) of the eye through an area.

JETTY - (1) (U.S. usage) On open seacoasts, a structure extending into a body of water, and designed to prevent shoaling of a channel by littoral materials, and to direct and confine the stream or tidal flow. Jetties are built at the mouth of a river or tidal inlet to help deepen and stabilize a channel. (2) (British usage) Jetty is synonymous with "wharf" or "pier".

LITTORAL - Of or pertaining to a shore, especially of the sea.

LITTORAL DEPOSITS - Deposits of littoral drift.

LITTORAL DRIFT - The sedimentary "material" moved in the littoral zone under the influence of waves and currents.

LITTORAL TRANSPORT - The "movement" of littoral drift in the littoral zone by waves and currents. Includes movement parallel (longshore transport) and perpendicular (on-offshore transport) to the shore.

LONGSHORE - Parallel to and near the shoreline.

LOW TIDE (LOW WATER, LW) - The minimum elevation reached by each falling tide.

LOW WATER LINE - The intersection of any standard low tide datum plane with the shore.

MARSH - An area of soft, wet, or periodically inundated land, generally treeless and usually characterized by grasses and other low growth.

MARSH, SALT - A marsh periodically flooded by salt water.

MEAN HIGH WATER (MHW) - The average height of the high waters over a 19-year period. For shorter periods of observations, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value. All high water heights are included in the average where the type of tide is either semidiurnal or mixed. Only the higher high water heights are included in the average where the type of tide is diurnal. So determined, mean high water in the latter case is the same as mean higher high water.

MEAN LOW WATER (MLW) - The average height of the low waters over a 19-year period. For shorter periods of observations, corrections are applied to eliminate known variations and reduce the results to the equivalent of a mean 19-year value. All low water heights are included in the average where the type of tide is either semidiurnal or mixed. Only lower low water heights are included in the average where the type of tide is diurnal. So determined, mean low water in the latter case is the same as mean lower low water.

MEAN SEA LEVEL - The average height of the surface of the sea for all stages of the tide over a 19-year period, usually determined from hourly height readings. Not necessarily equal to MEAN TIDE LEVEL.

## Appendix B

NEARSHORE (ZONE) - In beach terminology an indefinite zone extending seaward from the shoreline well beyond the breaker zone. It defines the area of NEARSHORE CURRENTS.

OVERTOPPING - Passing of water over the top of a structure as a result of wave runup or surge action.

OVERWASH - That portion of the uprush that carries over the crest of a berm or of a structure.

PIER - A structure, usually of open construction, extending out into the water from the shore, to serve as a landing place, a recreational facility, etc., rather than to afford coastal protection. In the Great Lakes, a term sometimes improperly applied to jetties.

PILE - A long, heavy timber or section of concrete or metal to be driven or jettied into the earth or seabed to serve as a support or protection.

POCKET BEACH - A beach, usually small, in a coastal re-entrant or between two littoral barriers.

POINT - The extreme end of a cape, or the outer end of any land area protruding into the water, usually less prominent than a cape.

PORT - A place where vessels may discharge or receive cargo; may be the entire harbor including its approaches and anchorages, or may be the commercial part of a harbor where the quays, wharves, facilities for transfer of cargo, docks, and repair shops are situated.

PROFILE, BEACH - The intersection of the ground surface with a vertical plane, may extend from the top of the dune line to the seaward limit of sand movement.

PROMONTORY - A high point of land projecting into a body of water; a HEADLAND.

REFLECTED WAVE - That part of an incident wave that is returned seaward when a wave impinges on a steep beach, barrier, or other reflecting surface.

REVTMENT - A facing of stone, concrete, etc., built to protect a scarp, embankment, or shore structure against erosion by wave action or currents.

RIPRAP - A layer, facing, or protective mound of stone randomly placed to prevent erosion, scour, or sloughing of a structure or embankment; also the stone so used.

RUBBLE - (1) Loose angular waterworn stones along a beach. (2) Rough, irregular fragments of broken rock.

RUBBLE-MOUND STRUCTURE - A mound of random-shaped and random-placed stones protected with a cover layer of selected stones or specially shaped concrete armor units. (Armor units in primary cover layer may be placed in orderly manner or dumped at random.)

RUNUP - The rush of water up a structure or beach on the breaking of a wave. Also UPRUSH. The amount of runup is the vertical height above stillwater level that the rush of water reaches.

SCOUR - Removal of underwater material by waves and currents, especially at the base or toe of a shore structure.

SEASHORE - The SHORE of a sea or ocean.

SEAWALL - A structure separating land and water areas, primarily designed to prevent erosion and other damage due to wave action.

SHINGLE - (1) Loosely and commonly, any beach material coarser than ordinary gravel, especially any having flat or flattish pebbles (2) Strictly and accurately beach material of smooth well-rounded pebbles that are roughly the same size. The spaces between pebbles are not filled with finer materials. Shingle often gives out a musical sound when stepped on.

SHOAL (noun) - A detached elevation of the sea bottom comprised of any material except rock or coral, which may endanger surface navigation.

SHORE - The narrow strip of land in immediate contact with the sea, including the zone between high and low water lines. A shore of unconsolidated material is usually called a beach.

SHORELINE - The intersection of a specified plane of water with the shore or beach (e.g. the highwater shoreline would be the intersection of the plane of mean high water with the shore or beach.) The line delineating the shoreline on U.S. Coast and Geodetic Survey nautical charts and surveys approximates the mean high water line.

SPIT - A small point of land or a narrow shoal projecting into a body of water from the shore.

STILLWATER LEVEL - The elevation that the surface of the water would assume if all wave action were absent.

**STORM SURGE** - A rise above normal water level on the open coast due to the action of wind stress on the water surface. Storm surge resulting from a hurricane also includes that rise in level due to atmospheric pressure reduction as well as that due to wind stress.

**SURF** - The wave activity in the area between the shoreline and the outermost limit of breakers.

**SURF ZONE** - The area between the outermost breaker and the limit of wave uprush.

**SWELL** - Wind-generated waves that have traveled out of their generating area. Swell characteristically exhibits a more regular and longer period, and has flatter crests than waves within their fetch.

**TIDAL RANGE** - The difference in height between consecutive high and low (or higher high and lower low) waters.

**TIDE** - The periodic rising and falling of the water that results from gravitational attraction of the moon and sun and other astronomical bodies acting upon the rotating earth. Although the accompanying horizontal movement of the water resulting from the same cause is also sometimes called the tide, it is preferable to designate the latter as TIDAL CURRENT, reserving the name TIDE for the vertical movement.

**TOMBOLO** - A bar or spit that connects or "ties" an island to the mainland or to another island.

**TROPICAL STORM** - A tropical cyclone with maximum winds less than 75 mph.

**WATERLINE** - A juncture of land and sea. This line migrates, changing with the tide or other fluctuation in the water level. Where waves are present on the beach, this line is also known as the limit of backrush. (Approximately the intersection of the land with the still-water level).

**WAVE REFLECTED** - That part of an incident wave that is returned seaward when a wave impinges on a steep beach, barrier, or other reflecting surface.

**WHARF** - A structure built on the shore of a harbor, river, or canal, so that vessels may lie alongside to receive and discharge cargo and passengers.

**MASSACHUSETTS**

**COASTAL STUDY**

**PUBLIC LAWS**

**PREPARED BY THE  
NEW ENGLAND DIVISION  
CORPS OF ENGINEERS  
DEPARTMENT OF THE ARMY**

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# PUBLIC LAWS

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APPENDIX C

PUBLIC LAW 520, 71ST CONGRESS  
Approved July 3, 1930

Be it enacted by the Senate and the House of Representatives of the United States in Congress assembled, that -----

SEC. 2 . . . . . The Chief of Engineers of the United States Army, under the direction of the Secretary of War, is authorized and directed to cause investigations and studies to be made in cooperation with the appropriate agencies of various States on the Atlantic, Pacific, and Gulf coasts and on the Great Lakes, and the Territories, with a view to devising effective means of preventing erosion of the shores of coastal and lake waters by waves and currents; and any expenses incident and necessary thereto may be paid from funds appropriated for examinations, Surveys and Contingencies for Rivers and Harbors: Provided, That the War Department may release to the appropriate State agencies information obtained by these investigations and studies prior to the formal transmission of reports to Congress: Provided further, That no money shall be expended under authority of this section in any State which does not provide for cooperation with the agents of the United States and contribute to the project such funds and/or services as the Secretary of War may deem appropriate and require; that there shall be organized under the Chief of Engineers, United States Army, by detail from time to time from the Corps of Engineers and from the engineers of State agencies charged with beach erosion and shore protection, a board of seven members, of whom four shall be officers of the Corps of Engineers and three shall be selected with regard to their special fitness by the Chief of Engineers from among the State agencies cooperating with the War Department. The board will furnish such technical assistance as may be directed by the Chief of Engineers in the conduct of such studies as may be undertaken and will review the reports of the investigations made. In the consideration of such studies as may be referred to the board by the Chief of Engineers, the board shall, when it considers it necessary and with the sanction of the Chief of Engineers, make, as a board or through its members, personal examinations of localities under investigation: Provided further, That the salary of the civilian members shall be paid by their respective States, but the traveling and other necessary expenses connected with their duties on the board shall be paid in accordance with the law and regulations governing the payment of such expenses to civilian employees of the Engineer Department.

PUBLIC LAW 409, 74TH CONGRESS  
Approved August 30, 1935

SEC. 5. Every report submitted to Congress in pursuance of any provisions of law for preliminary examination and survey looking to the improvement of the entrance at the mouth of any river or at any inlet, in addition to other information which the Congress has directed shall be given, shall contain information concerning the configuration of the shore line and the probable effect thereon that may be expected to result from the improvement having particular reference to erosion and/or accretion for a distance of not less than ten miles on either side of the said entrance.

PUBLIC LAW 166, 79TH CONGRESS  
Approved July 31, 1945

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That in addition to participating in cooperative investigations and studies with agencies of the various States as authorized in Section 2 of the River and Harbor Act, approved July 3, 1930, it shall be the duty of the Chief of Engineers, through the Beach Erosion Board to make general investigations with a view to preventing erosion of the shores of the United States by waves and currents and determining the most suitable methods for the protection, restoration, and development of beaches; and to publish from time to time such useful data and information concerning the erosion and protection of beaches and shore lines as the Board may deem to be of value to the people of the United States. The cost of the general investigations herein authorized shall be borne wholly by the United States. As used in this Act, the word "shores" includes the shore lines of the Atlantic and Pacific Oceans, the Gulf of Mexico, the Great Lakes, Lake Champlain, and estuaries and bays directly connected therewith.

SEC. 2. All provisions of existing law relating to examinations and surveys and to works of improvement of rivers and harbors shall apply, insofar as practicable, to examinations and surveys and to works of improvement relating to shore protection; except that all projects having to do with shore protection shall be referred for consideration and recommendation to the Beach Erosion Board instead of to the Board of Engineers for Rivers and Harbors.

SEC. 3. The Beach Erosion Board, in making its report on any cooperative investigation and studies under the provisions of Section 2 of the River and Harbor Act, approved July 3, 1930, relating to shore protection work shall, in addition to any other matters upon which it may be required to report, state its opinion as to (a) the advisability of adopting the project; (b) what public interest, if any, is involved in the proposed improvement; and (c) what share of the expense, if any, should be borne by the United States.

SEC. 4. Any expenses incident and necessary in the undertaking of the general investigations authorized herein may be paid from funds hitherto or hereafter appropriated for examinations, surveys, and contingencies for rivers and harbors.

PUBLIC LAW 727, 79TH CONGRESS, Approved August 13, 1946  
as amended by

PUBLIC LAW 826, 84TH CONGRESS, Approved July 28, 1956  
PUBLIC LAW 874, 87TH CONGRESS, Approved October 23, 1962, and  
PUBLIC LAW 298, 89TH CONGRESS, Approved October 27, 1965  
PUBLIC LAW 611, 91ST CONGRESS, Approved December 31, 1970  
PUBLIC LAW 587, 94TH CONGRESS, Approved December 22, 1976

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That (a) with the purpose of preventing damage to the shores of the United States, its Territories and possessions and promoting and encouraging the healthful recreation of the people, it is hereby declared to be the policy of the United States, subject to the following provisions of this Act to assist in the construction but not the maintenance, of works for the restoration and protection against erosion, by waves and current, of the shores of the United States, its Territories and possessions.

(b) The federal contribution in the case of any project referred to in subsection (a) shall not exceed one-half of the cost of the project, and the remainder shall be paid by the state, municipality, or other political subdivision in which the project is located except that (1) the costs allocated to the restoration and protection of federal property shall be borne fully by the federal government, (2) federal participation in the cost of a project for restoration and protection of state, county, and other publicly owned shore parks and conservation areas may be, in the discretion of the Chief of Engineers, not more than 70 per cent of the total cost exclusive of land costs, when such areas: Include a zone which excludes permanent human habitation; include but are not limited to recreational beaches, satisfy adequate criteria for conservation and development of the natural resources of the environment; extend landward a sufficient distance to include, where appropriate, protective dunes, bluffs, or other natural features which serve to protect the uplands from damage; and provide essentially full park facilities for appropriate public use, all of which shall meet with the approval of the Chief of Engineers, and (3) federal participation in the cost of a project providing hurricane protection may be, in the discretion of the Secretary of the Army, acting through the Chief of Engineers, not more than 70 per centum of the total cost exclusive of land costs.

(c) When in the opinion of the Chief of Engineers the most suitable and economical remedial measures would be provided by periodic beach nourishment, the term "construction" may be constructed for the purposes of this Act to include the deposit of sand fill at suitable intervals of time to furnish sand supply to project shores for a length of time specified by the Chief of Engineers.

(d) Shores other than public will be eligible for federal assistance if there is benefit such as that arising from public use or from the protection of nearby public property or if the benefits to those shores are incidental to the project, and the federal contribution to the project shall be adjusted in accordance with the degree of such benefits.

(e) No federal contribution shall be made with respect to a project under this Act unless the plan therefor shall have been specifically adopted and authorized by Congress after investigation and study by the Beach Erosion Board under the provisions of Section 2 of the River and Harbor Act approved July 3, 1930, as amended and supplemented, or, in the case of a small project under Section 3 of this Act, unless the plan therefor has been approved by the Chief of Engineers.

SEC. 2. The Secretary of the Army is hereby authorized to reimburse local interests for work done by them, after initiation of the survey studies which form the basis for the project, on authorized projects which individually do not exceed \$1,000,000 in total cost: Provided, That the work which may have been done on the projects is approved by the Chief of Engineers as being in accordance with the authorized projects: Provided further, That such reimbursement shall be subject to appropriations applicable thereto or funds available therefor and shall not take precedence over other pending projects of higher priority for improvements.

SEC. 3. The Secretary of the Army is hereby authorized to undertake construction of small shore and beach restoration and protection projects not specifically authorized by Congress, which otherwise comply with section 1 of this Act, when he finds that such work is advisable, and he is further authorized to allot from any appropriations hereafter made for civil works, not to exceed \$25,000,000 for any one fiscal year for the federal share of the costs of construction of such projects: Provided, That not more than \$1,000,000 shall be allotted for this purpose for any single project and the total amount allotted shall be sufficient to complete the federal participation in the project under this section including periodic nourishment as provided for under section 1 (c) of this Act: Provided further, That the provisions of local cooperation specified in section 1 of this Act shall apply:

And provided further, That the work shall be complete in itself and shall not commit the United States to any additional improvement to insure its successful operation, except for participation in periodic beach nourishment in accordance with section 1 (c) of this Act, and as may result from the normal procedure applying to projects authorized after submission of survey reports."

(b) All provisions of existing law relating to surveys of rivers and harbors shall apply to surveys relating to shore protection and section 2 of the River and Harbor Act approved July 3, 1930, as amended (33 U.S.C. 426), is modified to the extent inconsistent herewith.

(c) The cost-sharing provisions of this Act shall apply in determining the amounts of federal participation in or payments toward the costs of authorized projects which have not been substantially completed prior to the date of approval of this Act, and the Chief of Engineers, through the Beach Erosion Board, is authorized and directed to recompute the amounts of Federal contribution toward the costs of such projects accordingly.

SEC. 4. As used in this Act, the word "shores" includes all the shorelines of the Atlantic and Pacific Oceans, the Gulf of Mexico, the Great Lakes, and lakes, estuaries, and bays directly connected therewith.

#### PUBLIC LAW 71, 84TH CONGRESS

Approved June 15, 1955

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That in view of the severe damage to the coastal and tidal areas of the eastern and southern United States from the occurrence of hurricanes, particularly the hurricanes of August 31, 1954, and September 11, 1954, in the New England, New York, and New Jersey coastal and tidal areas, and the hurricane of October 15, 1954, in the coastal and tidal areas extending south to South Carolina, and in view of the damages caused by other hurricanes in the past, the Secretary of the Army, in cooperation with the Secretary of Commerce and other federal agencies concerned with hurricanes, is hereby authorized and directed to cause an examination and survey to be made of the eastern and southern seaboard of the United States with respect to hurricanes, with particular reference to areas where severe damages have occurred.

SEC. 2. Such survey, to be made under the direction of the Chief of Engineers, shall include the securing of data on the behavior and frequency of hurricanes, and the determination of methods of forecasting their paths and improving warning services, and of possible means of preventing loss of human lives and damages to property, with due consideration of the economics of proposed breakwaters, seawalls, dikes, dams, and other structures, warning services, or other measures which might be required.

SEC. 3. There are hereby authorized to be appropriated such sums as may be necessary to carry out the provisions of this Act.

PUBLIC LAW 874, 87TH CONGRESS, Approved October 23, 1962  
as amended by  
PUBLIC LAW 298, 89TH CONGRESS, Approved October 27, 1965

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled . . . . .

SEC. 101. (Authorizes certain navigation and beach erosion projects).

SEC. 102. That the Secretary of the Army is hereby authorized to reimburse local interests for such work done by them on the beach erosion projects authorized in Section 101, and in other sections of this Act, subsequent to the initiation of the cooperative studies which form the basis for the projects: Provided, That the work which may have been done on these projects is approved by the Chief of Engineers as being in accordance with the projects herein adopted: Provided further, That such reimbursement shall be subject to appropriations applicable thereto or funds available therefor and shall not take precedence over other pending projects of higher priority for improvements.

SEC. 103. (Amends Public Law 727, 79th Congress as amended by Public Law 826, 84th Congress).

SEC. 110. The Secretary of the Army is hereby authorized and directed to cause . . . . . Surveys of the coastal areas of the United States and its possessions, including the shores of the Great Lakes, in the interest of beach erosion control, hurricane protection and related purposes: Provided, That surveys of particular areas shall be authorized by appropriate resolutions of either the Committee on Public Works of the United States Senate or the Committee on Public Works of the House of Representatives.

PUBLIC LAW 172, 88TH CONGRESS  
Approved November 7, 1963

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Board established by Section 2 of the River and Harbor Act approved July 3, 1930, as amended (33 U.S.C. 426), referred to as the Beach Erosion Board, is hereby abolished. There shall be established under the Chief of Engineers, United States Army, a Coastal Engineering Research Center which, except as hereinafter provided in Section 3 hereof, shall be vested with all the functions of the Beach Erosion Board, including the authority to make general investigations as provided in Section 1 of the Act approved July 31, 1945 (59 Stat. 508), and such additional functions as the Chief of Engineers may assign.

SEC. 2. The functions of the Coastal Engineering Research Center established by Section 1 of this Act, shall be conducted with the guidance and advice of a Board on Coastal Engineering Research, constituted by the Chief of Engineers in the same manner as the present Beach Erosion Board.

SEC. 3. All functions of the Beach Erosion Board pertaining to review of reports of investigations made concerning erosion of the shores of coastal and lake waters, and the protection of such shores, are hereby transferred to the Board established by Section 3 of the River and Harbor Act approved June 13, 1902, as amended (33 U.S.C. 541), referred to as the Board of Engineers for Rivers and Harbors.

PUBLIC LAW 483, 90TH CONGRESS  
Approved August 13, 1968

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled . . . . .

SEC. 106. (a) The Chief of Engineers, Department of the Army, under the direction of the Secretary of the Army, shall make an appraisal investigation and study, including a review of any previous relevant studies and reports, of the Atlantic, Gulf, and Pacific coasts of the United States, the coasts of the United States, the coasts of Puerto Rico and the Virgin Islands, and the shorelines of the Great Lakes, including estuaries and bays thereof, for the purpose of (1) determining areas along such coasts and shorelines where significant erosion occurs; (2) identifying those areas where erosion presents a serious problem because the rate of erosion, considered in conjunction with economic, industrial, recreational, agricultural, navigational, demographic, ecological, and other relevant factors, indicates that action to halt such erosion may be justified; (3) describing generally the most suitable type of remedial action for those areas that have a serious erosion problem; (4) providing preliminary cost estimates for such remedial action; (5) recommending priorities among the serious

problem areas for action to stop erosion; (6) providing state and local authorities with information and recommendations to assist the creation and implementation of state and local coast and shoreline erosion programs; (7) developing recommended guidelines for land use regulation in coastal areas taking into consideration all relevant factors; and (8) identifying coastal areas where title uncertainty exist. The Secretary of the Army shall submit to the Congress as soon as practicable, but not later than three years after the date of enactment of this Act, the results of such appraisal investigation and study, together with his recommendations. The views of concerned local, state, and federal authorities and interests will be taken into account in making such appraisal investigation and study.

(b) There are authorized to be appropriated such amounts, not to exceed \$1,000,000, as may be necessary to carry out the provisions of this section . . .

SEC. 111. The Secretary of the Army, acting through the Chief of Engineers, is authorized to investigate, study, and construct projects for the prevention or mitigation of shore damages attributable to federal navigation works. The cost of installing, operating, and maintaining such projects shall be borne entirely by the United States. No such project shall be constructed without specific authorization by Congress if the estimated first cost exceeds \$1,000,000 . . .

SEC. 215. (a) The Secretary of the Army, acting through the Chief of Engineers, may, when he determines it to be in the public interest, enter into agreements providing for reimbursement to States or political subdivisions thereof for work to be performed by such non-federal public bodies at water resources development projects authorized for construction under the Secretary of the Army and the supervision of the Chief of Engineers. Such agreements may provide for reimbursement of installation costs incurred by such entities or an equivalent reduction in the contributions they would otherwise be required to make, or in appropriate cases, for a combination thereof. The amount of federal reimbursement, including reductions in contributions, for a single project shall not exceed \$1,000,000.

(b) Agreements entered into pursuant to this section shall (1) fully describe the work to be accomplished by the non-federal public body, and be accompanied by an engineering plan if necessary therefor; (2) specify the manner in which such work shall be carried out; (3) provide for necessary review of design and plans, and inspection of the work by the Chief of Engineers or his designee; (4) state the basis on which the amount of reimbursement shall be determined; (5) state that such reimbursement shall be dependent upon the appropriation of funds applicable thereto or available

therefor, and shall not take precedence over other pending projects of higher priority for improvements; and (6) specify that reimbursement or credit for non-federal installation expenditures shall apply only to work undertaken on federal projects after project authorization and execution of the agreement, and does not apply retroactively to past non-federal work. Each such agreement shall expire three years after the date on which it is executed if the work to be undertaken by the non-federal public body has not commenced before the expiration of that period. The time allowed for completion of the work will be determined by the Secretary of the Army, acting through the Chief of Engineers, and stated in the agreement.

(c) No reimbursement shall be made, and no expenditure shall be credited, pursuant to this section, unless and until the Chief of Engineers or his designee, has certified that the work for which reimbursement or credit is requested has been performed in accordance with the agreement.

(d) Reimbursement for work commenced by non-federal public bodies no later than one year after enactment of this section, to carry out or assist in carrying out projects for beach erosion control, may be made in accordance with the provisions of section 2 of the Act of August 13, 1946, as amended (33 U S C. 426f). Reimbursement for such work may, as an alternative, be made in accordance with the provisions of this section, provided that agreement required herein shall have been executed prior to commencement of the work. Expenditures for projects for beach erosion control commenced by non-federal public bodies subsequent to one year after enactment of this section may be reimbursed by the Secretary of the Army, acting through the Chief of Engineers, only in accordance with the provisions of this section.

(e) This section shall not be construed (1) as authorizing the United States to assume any responsibilities placed upon a non-federal body by the conditions of project authorization, or (2) as committing the United States to reimburse non-federal interests if the federal project is not undertaken or is modified so as to made the work performed by the non-federal Public body no longer applicable.

(f) The Secretary of the Army is authorized to allot from any appropriations hereafter made for civil works, not to exceed \$10,000,000 for any one fiscal year to carry out the provisions of this section. This limitation does not include specific project authorizations providing for reimbursement.

PUBLIC LAW 93-251, 93rd Congress  
Approved March 7, 1974

Be it enacted by the Senate and the House of Representatives of the United States of America in Congress assembled, that . . . .

SEC. 54. (a) This section may be cited as the "Shoreline Erosion Control Demonstration Act of 1974".

(b) The Congress finds that because of the importance and increasing interest in the coastal and estuarine zone of the United States, the deterioration of the shoreline within this zone due to erosion, the harm to water quality and marine life from shoreline erosion, the loss of recreational potential due to such erosion, the financial loss to private and public landowners resulting from shoreline erosion, and the inability of such landowners to obtain satisfactory financial and technical assistance to combat such erosion, it is essential to develop, demonstrate, and disseminate information about low-cost means to prevent and control shoreline erosion. It is therefore the purpose of this section to authorize a program to develop and demonstrate such means to combat shoreline erosion.

(c) (1) The Secretary of the Army, acting through the Chief of Engineers, shall establish and conduct for a period of five fiscal years a national shoreline erosion control development and demonstration program. The program shall consist of planning, constructing, operating, evaluating, and demonstrating prototype shoreline erosion control devices, both engineered and vegetative.

(2) The program shall be carried out in cooperation with the Secretary of Agriculture, particularly with respect to vegetative means of preventing and controlling shoreline erosion, and in cooperation with federal, state, and local agencies, private organizations, and the Shoreline Erosion Advisory Panel established pursuant to subsection (d).

(3) Demonstration projects established pursuant to this section shall emphasize the development of low-cost shoreline erosion control devices located on sheltered or inland waters. Such projects shall be undertaken at no less than two sites each on the shorelines of the Atlantic, Gulf and Pacific coasts, the Great Lakes, and the State of Alaska, and at locations of serious erosion along the shores of Delaware Bay, particularly at those reaches known as Pickering Beach, Kitts Hummock, Bowers, Slaughter Beach, Broadkill Beach, and Lewes in the state of Delaware. Sites selected should, to the extent possible, reflect a variety of geographical and climatic conditions.

(4) Such demonstration projects may be carried out on private or public lands except that no funds appropriated for the purpose of this section may be expended for the acquisition of privately owned lands. In the case of sites located on private or non-federal public lands, the demonstration projects shall be undertaken in cooperation with a non-federal sponsor or sponsors who shall pay at least 25 per centum of construction costs at each site and assume operation and maintenance costs upon completion of the project.

(d) (1) No later than one hundred and twenty days after the date of enactment of this section the Chief of Engineers shall establish a Shoreline Erosion Advisory Panel. The Chief of Engineers shall appoint fifteen members to such Panel from among individuals who are knowledgeable with respect to various aspects of shoreline erosion, with representatives from various geographical areas, institutions of higher education, professional organizations, state and local agencies, and private organizations, except that such individuals shall not be regular full-time employees of the United States. The Panel shall meet and organize within ninety days from the date of its establishment, and shall select a Chairman from among its members. The Panel shall then meet at least once each six months thereafter and shall expire ninety days after termination of the five-year program established pursuant to subsection (c).

(2) The Panel shall—

(A) advise the Chief of Engineers generally in carrying out provisions of this section;

(B) recommend criteria for the selection of development and demonstration sites;

(C) recommend alternative institutional, legal, and financial arrangements necessary to effect agreements with non-federal sponsors of project sites;

(D) make periodic reviews of the progress of the program pursuant to this section;

(E) recommend means by which the knowledge obtained from the project may be made readily available to the public; and

(F) perform such functions as the Chief of Engineers may designate.

(3) Members of the Panel shall, while serving on business of the Panel, be entitled to receive compensation at rates fixed by the Chief of Engineers, but not in excess of the maximum rate of pay for grade GS-18, as provided in the General Schedule under section

5332 of title 5 of the United States Code, including traveltime and while away from their homes or regular places of business, they may be allowed travel expenses, including per diem in lieu of subsistence, as authorized by law (5 U.S.C. 73b-2) for persons in Government service employed intermittently.

(4) The Panel is authorized, without regard to the civil service laws, to engage such technical and other assistance as may be required to carry out its functions.

(e) The Secretary of the Army, acting through the Chief of Engineers, shall prepare and submit annually a program progress report, including therein contributions of the Shoreline Erosion Advisory Panel, to the Committees on Public Works of the Senate and House of Representatives. The fifth and final report shall be submitted sixty days after the fifth fiscal year of funding and shall include a comprehensive evaluation of the national shoreline erosion control development and demonstration program.

(f) There is authorized to be appropriated for the first fiscal year following enactment of this section, and the succeeding four fiscal years, a total of not to exceed \$8,000,000 to carry out the provisions of this section.

SEC. 55. The Secretary of the Army, acting through the Chief of Engineers, is authorized to provide technical and engineering assistance to non-federal public interests in developing structural and non-structural methods of preventing damages attributable to shore and streambank erosion.

PUBLIC LAW 587, 94th Congress  
Approved October 22, 1976

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, that . . . . .

SEC. 145. The Secretary of the Army, acting through the Chief of Engineers, is authorized upon request of the State, to place on the beaches of such State beach-quality sand which has been dredged in constructing and maintaining navigation inlets and channels adjacent to such beaches, if the Secretary deems such action to be in the public interest and upon payment of the increased cost thereof above the cost required for alternative methods of disposing of such sand.

SEC. 156. The Secretary of the Army, acting through the Chief of Engineers, is authorized to provide periodic beach nourishment in the case of each water resources development project where such nourishment has been authorized for a limited period for such additional period as he determines necessary but in no event shall such additional period extend beyond the fifteenth year which begins after the date of initiation of construction of such project.